UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a Thesis entitled "Groundwater Resources of the Blindman River Valley," submitted by Grant LeRoy Nielsen in partial fulfillment of the requirements of the degree of Master of Science.

ABSTRACT

During late glacial and early post-glacial times, the Blindman River drainage basin was developed on the general slope to the Red Deer river. Two streams, one draining into the glacial Red Deer River and one into glacial Gull Lake, were probably present during glacial time. Modification of the drainage occurred in early post-glacial time, leading to the development of the present drainage pattern.

Two types of aquifers occur in the Blindman River valley: permeable sandstone lenses in the Tertiary Paskapoo Formation, and sands and gravels in surficial deposits. The former are more extensively developed and are economically more important. About thirty per cent of stream discharge during baseflow recession is calculated to be of groundwater origin.

Groundwater from wells in recharge areas is much harder than from wells in discharge areas, because in travelling through the bedrock to discharge areas, it is softened by ion-exchange in bentonitic materials. Water high in sulfates is also high in total solids. Groundwater from the Paskapoo Formation is chemically satisfactory and sufficiently abundant for municipal and industrial use.

The proposed scheme to employ groundwater for raising the level of Gull Lake would probably be unsuccessful, because of the great quantities required. An alternate method, reduction of evaporation, is suggested.

The interrelated phases of the hydrologic cycle are probably better studied on the basis of drainage basins rather than map quadrangles.

ACKNOWLEDGMENTS

The author wishes to express his gratitude to the staff of the Groundwater Division, Research Council of Alberta, whose help and many suggestions were greatly appreciated, especially those of Joseph Toth, who supervised this investigation.

Information provided by Amerada Petroleum Corporation, Texaco Exploration Company, Imperial Oil Limited, California Standard Oil Company, and the Oil and Gas Conservation Board greatly helped in the preparation of several figures and maps. The federal Department of Transport provided streamflow records and meteorologic data. The provincial Water Resources Branch supplied lake level measurements and reinstalled the streamflow gauge on the Blindman River.

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Plate 1. Outcrops of the Paskapoo Formation at the Mouth of the Blindman River

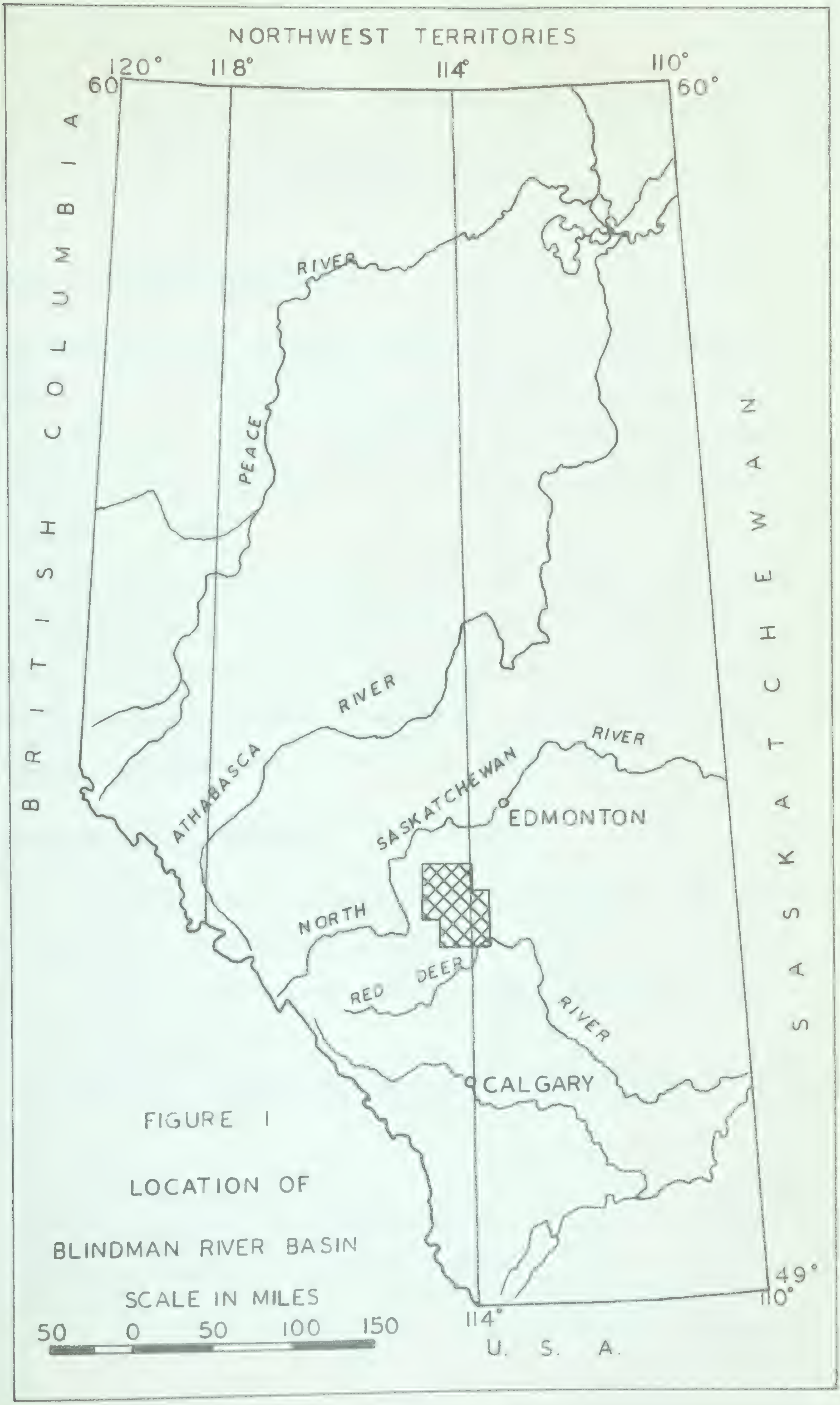


FIGURE 1

LOCATION OF

BLINDMAN RIVER BASIN

INTRODUCTION

PURPOSE AND SCOPE OF INVESTIGATION

The Research Council of Alberta is engaged in mapping the groundwater resources of Alberta, in order to assure their optimum development. The present investigation, as part of this program, was conducted to evaluate the groundwater resources in the Blindman valley. Field work was conducted during the summer of 1962.

The type section of the Paskapoo Formation is the bluffs at the mouth of the Blindman River. (Paskapoo means "blind man" in the local Indian language). The area is thus the lithologic, stratigraphic and groundwater standard for the entire formation. This was one of the principal reasons for choosing the Blindman River valley for the present study.

LOCATION OF AREA AND PHYSIOGRAPHY

The Blindman River drainage basin (Figure 1) is located in west central Alberta (52° 15' N. to 53° 00' N., and 113° 45' W. to 114° 40 W.) in the High Plains section of the Interior Plains. (Canada Dept. of Mines and Technical Surveys, 1957, Map 13).

Topographic maps covering the area include two sheets at the scale of 1:250,000:

Red Deer, 83 A

Rocky Mountain House, 83 B (Advance Print),

and the following sheets at the scales of 1:50,000:

Red Deer 83 A/5, West Half

Sylvan Lake 83 B/8, West Half and East Half

Ponoka, 83 A/12, West Half

Rimbey, 83 B/9, West Half and East Half

Carlos, 83 B/10, East Half

Winfield, 83 B/16, Advance Print

Buck Lake, 83 B/15, East Half

Both major railways and provincial highways 11, 12, 20, and 53, as well as good municipal highways serve the area.

The area of the basin is 710 square miles with most of the land being low rolling parkland. Maximum relief is about 900 feet, with the highest elevations in the Medicine Lodge Hills, which form the divide between Sylvan Lake and the Blindman River. The mean elevation, based on Wisler and Brater's intersection method (1959, p. 44) and calculated from 177 intersections, is 3082 feet.

In its lower reaches, the Blindman River flows in a steep valley, whereas to the north, the valley is broader with gently sloping sides.

CLIMATE, SOIL AND VEGETATION

The climate of the area is transitional from Humid Continental with Cool Summer, to Subartic (Canada Dept. of Mines and Technical Surveys, 1957, Map 30). The growing season is slightly in excess of 160 days (Ibid., Map 24). Average annual precipitation ranges from 17 inches in the southeast to 20 inches in the northeast, about 80 percent of which falls as summer rainfall (McKay, 1961, p.8).

Black soil occurs south of Gull Lake, whereas to the west and northwest, Dark Grey and Dark Grey Wooded types are present. North of Rimbey,

Grey Wooded soil occurs (Odynsky, 1962).

Typical parkland is present in the southeast where grassland has been partially invaded by trees. Tree cover (mainly aspen) increases northward and is thickest in the Grey Wooded soil area. Much of this forest was burned early in the century, and today few trees are large enough to warrant lumbering operations. The northern part of the basin is gradually being cleared for farming, but much still remains forested.

HISTORY AND PREVIOUS INVESTIGATIONS

David Thompson was probably the first European to visit the Blindman River area, when he made a track survey between Rocky Mountain House and Fort Edmonton in 1801. Governor Simpson of the Hudson's Bay Company passed Gull Lake on his journey across North America in 1841. About 1858 to 1859 Captain Palliser's expedition explored the agricultural potential of the area for the British Government. J.B. Tyrrell visited and described the country in 1886 for the Geological Survey of Canada.

Settlement began about 1900, after the Edmonton-Calgary railroad was built. Rimbey was founded in 1902 by settlers from Kansas, but most of the valley further north was not settled until after a railway was built from Lacombe to Rimbey in 1919.

The development of lumbering west of the area in the late 1930's, and the postwar oil and gas discoveries have contributed much to the economic growth of the area.

Except for that part of the basin east of the Fifth Meridian, little geologic work has been done. J.A. Allan spent some time near Gull Lake in 1942 in an attempt to determine geologic factors causing the drop in lake level. Allan and J.O.G. Sanderson (1946) mapped the bedrock geology east

of the Fifth Meridian as part of the Red Deer - Rosebud Sheet, and in 1947 and 1948, the Geological Survey of Canada published Water Survey papers for this same area. The Geological Survey also collected some water well data in the area immediately west of Gull Lake in 1950, but they were not published. These data are included in Appendix E. The surficial geology of the Red Deer - Stettler map-area was mapped by A. Stalker, in 1960.

GEOLOGY

PASKAPOO FORMATION

The Paskapoo Formation (Tyrrell, 1886) was considered Upper Paleocene in age by Russell (In Allan and Rutherford, 1934, p. 25). It appears to rest unconformably on the Edmonton Formation. (Ibid) Thickness of the formation increases from about 200 feet to 1200 feet from east to west within the area of investigation (Figure 9 A). The formation is non-marine and appears to have been deposited by large rivers on a poorly drained flood plain. Large scale cut-and-fill structures in outcrop and extreme lenticularity of sandstones in well records tend to support this mode of origin.

Fossils are not common in the Paskapoo Formation, although plant remains and small non-marine gastropods and pelecypods do occur.

Soft shale and clay are the dominant lithologies, but sandstone is also fairly common. Thin carbonaceous partings, conglomerate, bentonitic shale, limestone and coal also occur, but to a lesser extent.

The more porous sandstone lenses are the only important aquifers in the formation. Some sandstone lenses can be traced up to six miles, but most have an extent of less than one mile. Although the sandstone in some lenses is very hard and a steel-grey color, most is poorly indurated and a characteristic buff color. The lower 300 feet of the formation contain the most sandstone (Appendix C), but otherwise it is impossible to make detailed correlations across the basin.

SURFICIAL DEPOSITS

The term "Surficial Deposits", as used in this paper, includes all materials lying above the Paskapoo Formation, without respect to geologic age.

The Saskatchewan Sands and Gravels, of probable late Tertiary or Pleistocene age lie immediately above the Paskapoo Formation. They have sporadic distribution and probably represent pre-or early Pleistocene stream deposits. Outcrops occur one-quarter mile east of the confluence of the Red Deer and Blindman Rivers in the banks of the former. Except in the pre-glacial Red Deer River Channel, they are of little significance in the area of investigation.

Four materials of glacial and post-glacial age are also included with Surficial Deposits.

Till consists of a relatively impervious matrix of clay-sized particles, containing a heterogeneous assortment of pebbles, cobbles, and boulders. Irregular lenses of sand and gravel may be present. Till may be deposited in irregular hills, called hummocky moraine, or may form broad relatively flat plains.

Alluvial stream sands and gravels usually occur adjacent to the streams to which they owe their origin. They are well situated for continuous recharge from these streams, and as they are very permeable and sufficiently thick in many places, they can provide large water supplies.

Aeolian sand covers only a small area at the mouth of the Blindman River, where it forms low dunes. This sand is yellow in color, and rather fine grained. The deposits are probably too thin to be a reliable aquifer.

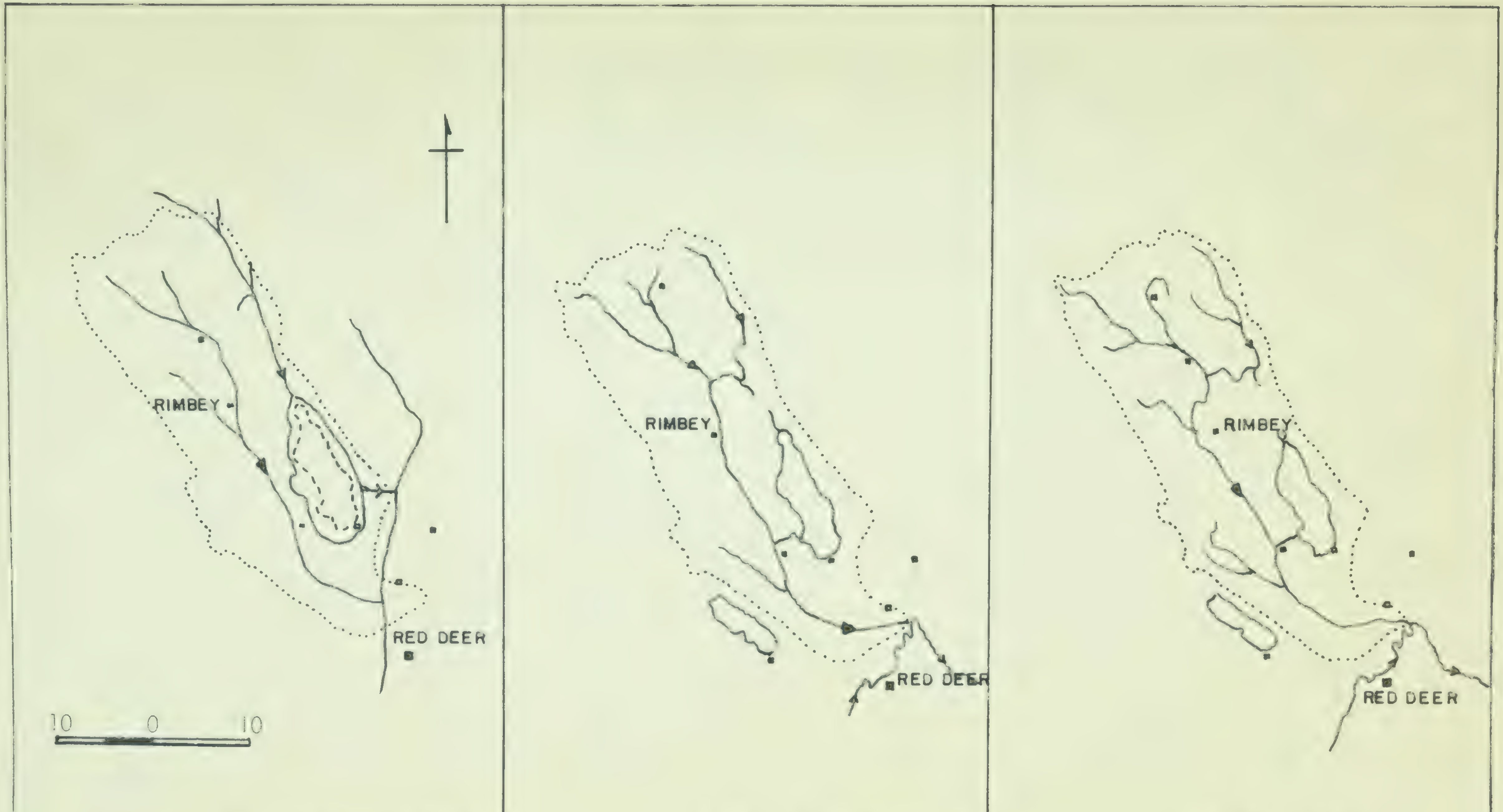
Coarse lake deposits and outwash gravels cover the area immediately surrounding and east of Gull Lake. Grain size ranges from medium sand to coarse gravel, frequently with a very fine grained matrix.

DRAINAGE DEVELOPMENT

Stalker (1960, p. 62) stated that the present Blindman River is an ice-

front or ice-marginal stream, the lower part first used during retreat of the last glacier.

Based on a study of surficial deposits and bedrock topography, the author believes that there were originally two discrete streams in the present Blindman Basin. (Figure 2). The more easterly, probably interglacial in age, carved a wide valley in which the northeast branch of the Blindman River flows at the present time. As this valley extends northward across the present topographic divide, the stream that originally formed it probably did so too. This divide is at present the site of a swamp several miles long, drained by streams flowing from both ends. The northeast branch of the Blindman River now turns west in Township 44, Range 1, West of the Fifth Meridian even though a wide bedrock channel continues south into Gull Lake. The southern part of this channel is filled with a poorly sorted hummocky moraine which undoubtedly dammed and diverted the stream that had flowed there. The name "Gull Lake Channel" is proposed for this bedrock channel. That it is of glacial and not of preglacial origin is concluded from the following observations. The channel is about two miles wide and 200 feet deep at the north end of Gull Lake, but there is no channel of comparable size leaving the lake. Lacustrine deposits around Gull Lake indicate that the lake was formerly much larger than at present, and probably of glacial origin. A small channel does exist east of Gull Lake in Township 41, Range 28, West of the Fourth Meridian, but it is poorly defined (Figure 17). It probably drained glacial Gull Lake for a short time into glacial Lake Red Deer which was then adjacent. The Gull Lake Channel cannot be traced down the regional slope to the Red Deer Channel, as it should be if it were of preglacial age. Moreover, sand and gravel deposits usually lie directly on bedrock in preglacial channels, but in the Gull Lake Channel,



1. Late Glacial Stage

2. Early Post-Glacial Stage

3. Recent Stage

FIGURE 2. DEVELOPMENT OF THE DRAINAGE PATTERN OF THE BLINDMAN R. BASIN

any sand and gravel present overlies till.

The northwest, or main branch of the Blindman River incised rapidly (Stalker, 1960, p. 90). It formerly flowed in an almost straight south-southeast direction from its headwaters as far as the Bentley area, where it turned east. In doing so, it created the broad valley one mile north and east of Rimbey (Figure 2). This valley contains little buried sand or gravel, although boulders have been reported in drilling there. Later, however, the river cut a deep valley which it now occupies one-half mile west of Rimbey. This valley is steep and narrow with many bedrock exposures along its flanks. The present stream rejoins the original channel three miles south-east of Rimbey.

When the eastward drainage from Gull Lake was blocked, probably through deposition of glacial material, a new outlet was found in the small stream draining southwest from the lake near Bentley. Lake level is too low for this stream to flow at the present time, but in the 1920's discharge was great enough that a hydroelectric development was begun.

HYDROLOGY

INTRODUCTION

The Blindman drainage basin was chosen for a hydrologic study for several reasons. The Paskapoo Formation was named and described from the buff sandstone exposures at the mouth of the stream, and because it underlies the entire basin, this is one of the best areas to observe and measure its groundwater characteristics. This area, being the lithologic and stratigraphic type section of the formation, those groundwater characteristics measured and observed will constitute the "groundwater type section" as well.

HYDROLOGIC CHARACTERISTICS AND BUDGET OF THE BASIN

The Blindman River forms a dendritic system, draining an area of 710 square miles. The Gravelius "form factor" (Wisler and Brater, 1959, p. 43), defined as the ratio of average width to axial length of the basin, is 13.8: 50.5, or 0.27. Axial length is the distance from the mouth of the stream to the point furthest from it on the drainage divide. Average width is the area divided by the axial length. Because storms vary in intensity from place to place and usually have one or a small number of foci of greatest precipitation, a relatively long, narrow drainage basin (with a low "form factor") is less likely to have simultaneous intense rainfall over its entire area than a fairly round one (with a high "form factor") of the same area. A low "form factor" such as 0.27 therefore indicates little possibility of peak precipitation over the entire basin simultaneously, and therefore little possibility of flooding.

The main branch of the river has total length of 60 miles and an average

FIGURE 3. STREAM ORDER DIAGRAM

slope of 9.6 feet per mile.

Analysis of topographic maps of the basin on a scale of 1:50,000 reveals 106 permanent and intermittent streams of first order, 25 second order, six of third order, and one of fourth order. A first order stream is one which has no tributaries. A second order stream is formed by the intersection of two or more first order streams, and so on. (Wisler and Brater, 1959, p. 48). The number of streams usually decreases in a geometric fashion with ascending order, and does so in this case. Figure 3 shows this graphically, using reverse order for the sake of convenience. That is, the fourth order stream, or main one, becomes first order, the next order becomes second order, etc. For each reverse order, the logarithm of the number of streams per 100 square miles of basin area is calculated. A plot of logarithm versus the reverse order yields approximately a straight line (Figure 3).

The curve may be expressed by the equation

$$\log N = K\, O_R - C \qquad (1)$$

where N = number of streams of reverse order O_R per 100 square miles of drainage

K = slope of the curve

O_R = reverse stream order

C = negative value of $\log N$ when $O_R = 0$.

For the Blindman River, values of K and C calculated from Figure 3 give the following equation

$$\log N = 1.01\, O_R - 2.86.$$

The significance of particular numerical values of K and C is not fully understood at present. However, it appears that the slope (K) is almost

constant for all the drainage systems of a region (Ibid. p. 50, 51). Concerning the application of this analysis, Wisler and Brater (p. 51) stated:

> As to what particular characteristics of basin affect the values of K and C, little is at present known. However, there can be but little question that there is a close relationship between these constants and certain drainage - basin characteristics, which in turn are closely related to stream flow. Here in all probability lies a fertile field for research. No one can predict the extent of possibilities of correlating these factors and determining thereby the stream-flow characteristics based entirely upon the type of drainage net.

The Blindman River basin contains a total of 138 streams, giving a density of 0.19 streams per square mile. Caution must be used in comparing stream densities of different areas, because the concept does not take into account the size or length of streams, whether they are perennial or intermittent, or the presence of lakes. The density for the Medicine River basin, immediately west of the Blindman River is about 0.23 streams per square mile. That density is slightly higher than in the Blindman River basin is probably due to increased precipitation nearer the Rocky Mountains, and lack of large lakes. Other factors being equal, stream density is highest in areas of intense rainfall and relatively impervious soil and bedrock.

Daily streamflow records were kept by the Water Resources Branch of the federal Department of Northern Affairs and Natural Resources for only $6\frac{1}{2}$ years - from April, 1916, to December, 1922. At the request of the Research Council of Alberta, a gauge was reinstalled by the Water Resources Branch in the spring of 1962. Only the earlier records have been analysed in this study, although the 1962 records are included in Figure 4. During the years of record, minimum and maximum discharge were respectively 0.5 cfs (cubic feet per second, cusecs, or second - feet), and 7398 cfs. As an empirical rule, each baseflow recession, or period of time during which a portion of stream discharge is derived from effluent groundwater seepage, is assumed to start

two days after the peak of runoff, and to continue until the next significant increase of stream discharge (Kunkle, 1962, p. 1546).

In general, the following analysis was obtained by Meyboom's technique (1961 b, p. 1209), using Butler's equations (1959, p. 217), in order to facilitate comparison with Meyboom's analysis of the Elbow River records. Where annual averages or totals are given (Figure 5), the 1916 data are omitted, as they are incomplete. No measurements were taken during the last 15 days of December, 1922, but these were estimated, inasmuch as discharge is only about 1 cfs at this time of year.

By plotting stream hydrographs with an arithmetic time scale and logarithmic discharge scale, it is possible to show baseflow recession as a straight line curve, thus simplifying calculations (Figure 4).

In this analysis, interflow, or water which infiltrates the soil surface and moves laterally through the upper soil layers to a stream channel, has been included in surface runoff, that water which travels over the ground surface to a channel (Linsley, Kohler, and Paulhus, 1958, pp. 149 - 150).

The total potential groundwater discharge (Q_{tp}) for each recession, if it had gone to completion, is calculated from Butler's (1959, p. 217) formula:

$$Q_{tp} = \int_{t_o}^{t_\infty} Q \, dt \tag{2}$$

$$= \left[\frac{-K_1K_2/2.3}{10^{t/K_2}}\right]_{t_o}^{t_\infty} = \left[\frac{-K_1K_2/2.3}{10^{t_\infty/K_2}}\right] - \left[\frac{-K_1K_2/2.3}{10^{t_o/K_2}}\right]$$

As t approaches infinity, the first member becomes negligible, and the equation is simplified to:

$$Q_{tp} = K_1K_2/2.3$$

Q_{tp} is the total potential groundwater discharge in cubic feet,

K_1 is Q at time $t = 0$,

K_2 is the time increment in days corresponding to one log cycle change in discharge.

Q is measured by the Water Resources Branch in cfs, but acre-feet per day is a more convenient unit for these calculations, so the conversion constant 1.9835 is introduced (1 acre-foot per day = 1.9835 cfs), thus:

$$Q_{tp} = 1.9835\, K_1\, K_2 / 2.3. \tag{4}$$

To convert acre-feet to inches over the drainage basin, equation (4) must be multiplied by

$$\frac{12}{710 \times 640} = 2.64 \times 10^{-5}. \tag{5}$$

Actual groundwater discharge is always less than potential discharge, because an aquifer does not become completely dewatered. Actual discharge was calculated from equation (2), except that the integral goes from time t_1 to time t_2. The actual discharge for each recession was then calculated as a percentage of total stream discharge for the same period. Remaining potential groundwater discharge is the difference between potential and actual discharge. At the end of a recession, therefore, a certain amount of potential discharge always remains. The total recharge at the beginning of the next recession is the new potential discharge minus the previous remaining potential discharge.

The change in storage is the increment to or the decrement from storage, from the beginning of one recession to the beginning of the next.

The calculation in Figure 5 show an average annual groundwater discharge

FIGURE 4

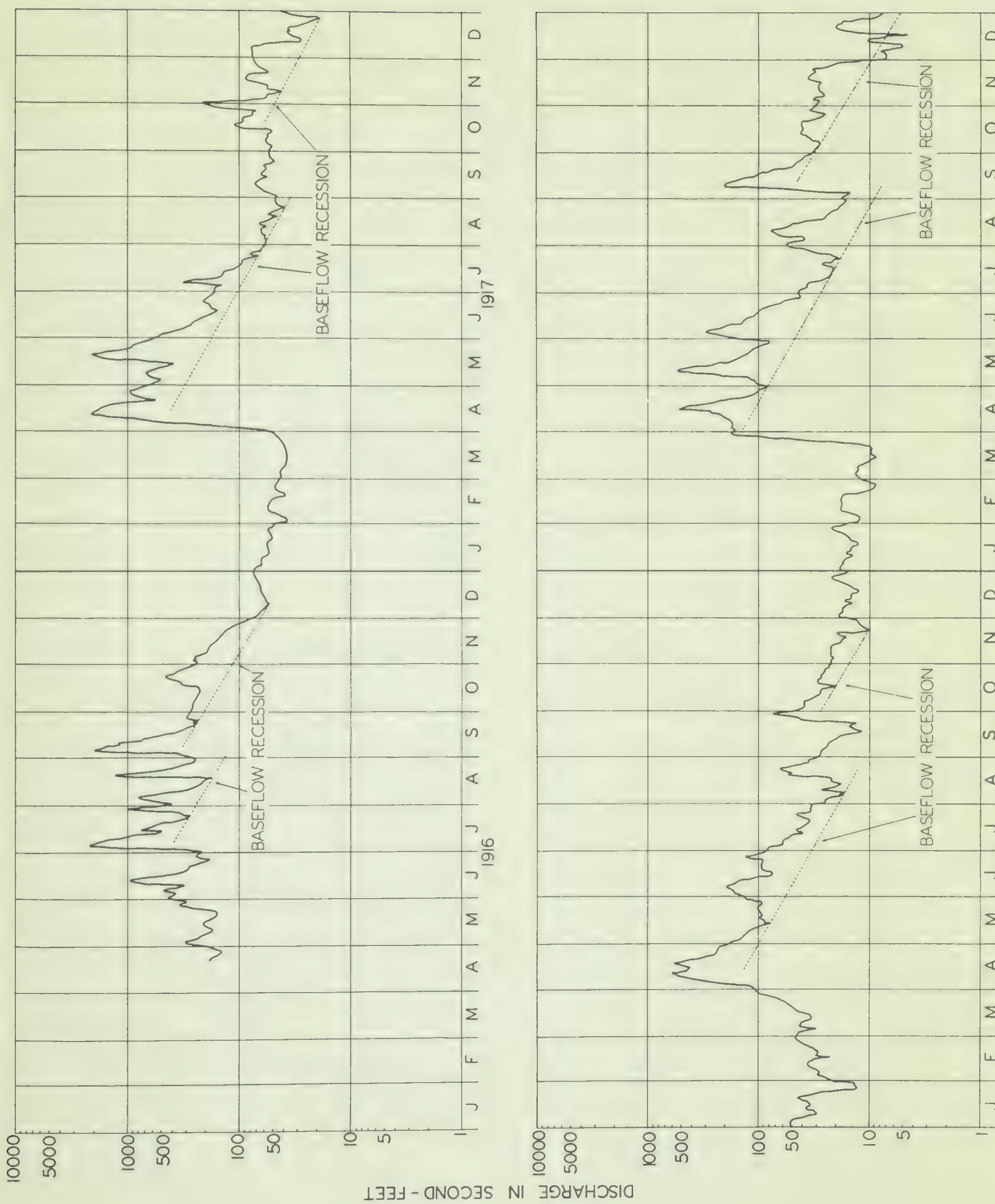
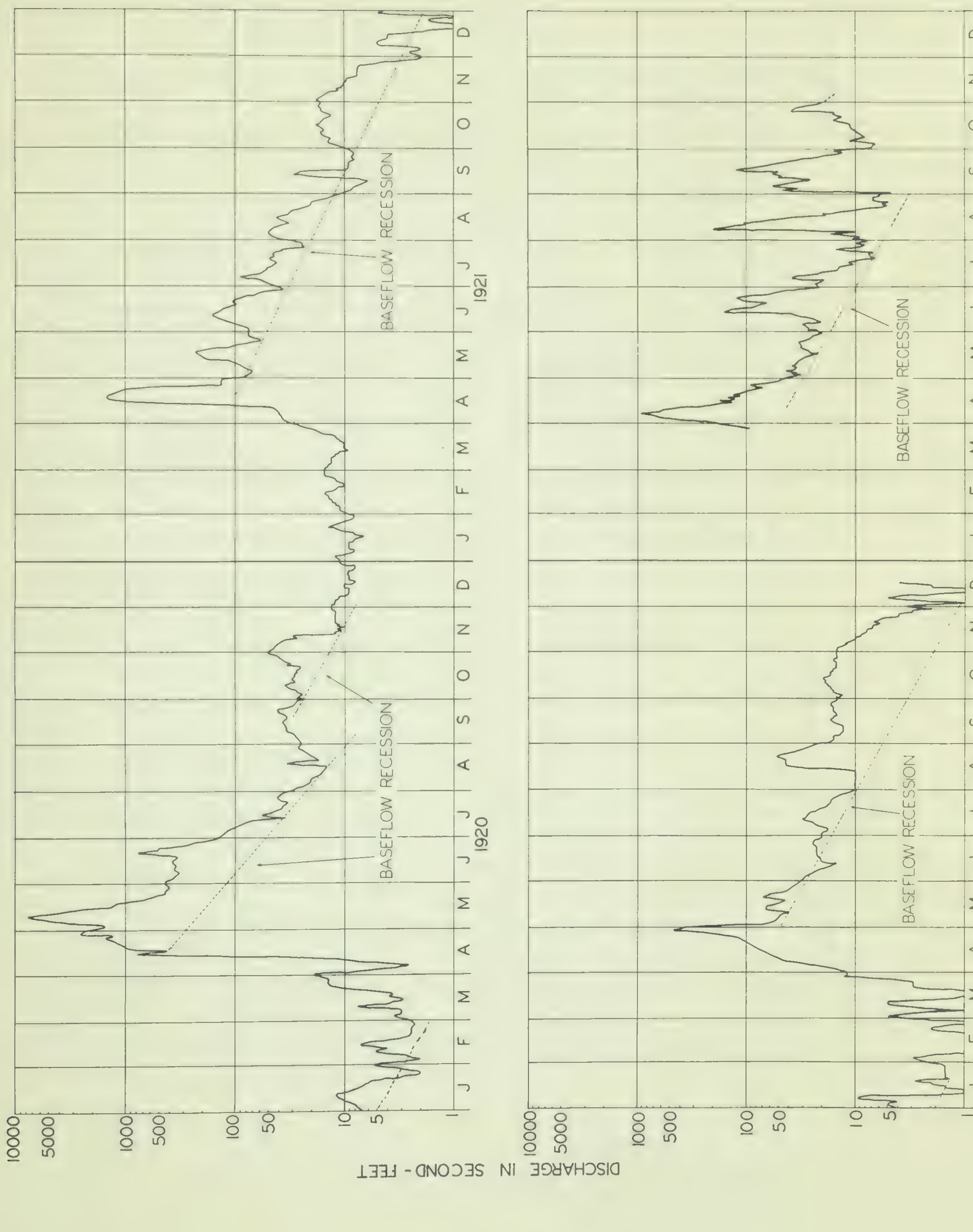


FIGURE 4. STREAMFLOW RECORDS OF THE BLINDMAN RIVER

FIGURE 4


DISCHARGE IN SECOND-FEET
10000
5000
1000
500
100
50
10
5
1
J F M A M J J A S O N D J F M A M J J A S O N D
1920
1921
1922
1962
BASEFLOW RECESSION
BASEFLOW RECESSION
BASEFLOW RECESSION
BASEFLOW RECESSION

CRITIQUE ON BASEFLOW RECESSION ANALYSIS

The baseflow recession curves shown in Fig. 4 are drawn, utilizing a few low points of the hydrographs plotted on semi-logarithmic paper, without using a consistent system. This method is not reliable because of the following:

1. The assumption that the baseflow recession curve plots as a straight line on semi-logarithmic paper over long periods of 5 to 6 months, is rather far-fetched.
2. During the periods that the baseflow recession is assumed to take place, no increase in baseflow was considered in spite of the occurrence of peak flows in the river. For example, during March 1917 a high flow of 2000 c.f.s. occurred, but no increase in baseflow was considered. Similarly high flows occurred during April 1916, March 1919, June and August 1962 and at several other times with no increase in baseflow.
3. On the other hand an increase in baseflow was assumed rather arbitrarily between:

   Aug. and Sept. 1916 - Peakflow reached approximately 2000 c.f.s.
   Aug. and Nov. 1917 - Peakflow reached approximately 200 c.f.s.
   Aug. and Oct. 1918 - Peakflow reached approximately 80 c.f.s.
   Aug. and Oct. 1919 - Peakflow reached approximately 200 c.f.s.
   Aug. and Oct. 1920 - Peakflow reached approximately 40 c.f.s.

Jac P. Verschuren
Associate Professor of
Civil Engineering

External Examiner

of about 0.58 inches, about one-fourth as much as Meyboom found for the Elbow River at Calgary (1961b, p. 1209). Baseflow was found to be 30 per cent of total flow in the Blindman River during recession, much less than that calculated by Meyboom for the Elbow River (Ibid.).

Bank storage is one of the most important ways by which groundwater contributes to streamflow. During high stage, a stream becomes influent and much of its flow infiltrates the alluvium and gravel along its banks. Later, as stream level drops, this flow is reversed, and the water that had been held in storage is released into the stream. The Elbow River has a wide, gravel-filled valley, allowing for a large volume of bank storage. Moreover, because the stream originates in the mountains, its gravel is probably coarser and more permeable than the fine material in the Blindman valley. In the latter, gravels are thin and not widespread, except in the upper part of the northeast branch. Much of the outwash gravel east of Gull Lake occurs in a topographically high area where little storage is possible. These factors explain the much smaller quantity of groundwater discharge in the Blindman River as compared to the Elbow River.

Groundwater discharge, as a fraction of total discharge, varies greatly from one season to another. As might be expected, it is lowest in spring and early summer, when the maximum runoff occurs. During autumn and winter, especially under freezing conditions, the proportion is much higher.

An average annual loss of 0.14 inches storage is indicated for the $6\frac{1}{2}$ years for which records are available. Whether this loss is a hydrologic adjustment to deforestation and cultivation of the land or merely a temporary condition, is impossible to ascertain with the amount of data available at present. Continuous streamflow records would be necessary for a long period of time, including several years previous to cultivation and ten or fifteen

years since the area was first intensely cultivated.

The water budget of any basin is expressed by the formula:

$$P = Q + E_v + \Delta S_g + \Delta S_m + \Delta S_w + U, \tag{6}$$

where P is average annual precipitation,

Q is surface runoff,

E_v is evapotranspiration,

ΔS_g is change in groundwater storage,

ΔS_m is change in soil-moisture storage,

ΔS_w is change in surface water storage,

U is underground flow to or from another basin.

All values are expressed in inches of precipitation over the drainage basin.

There are serious limitations to this analysis in the Blindman Basin. All records do not cover the same time interval, and the streamflow records especially cover only 6½ years. Whereas some data have been measured in the area of investigation, some have been measured at the Lacombe Experimental Farm, five miles east of the drainage basin. The latter may not be representative. No records of evapotranspiration are available and therefore it has been calculated solely as a figure to balance the equation.

Average annual precipitation at Lacombe from 1908 to 1961 was 16.84 inches. Surface runoff, calculated from the 6½ years of streamflow records of the Blindman River, is the difference between total stream discharge and that part of stream discharge contributed by baseflow, and was 1.42 inches annually. The change in groundwater storage was also analysed from the stream-flow records, and is an annual deficit of 0.14 inches for 1916 to 1922. The change in soil moisture storage, calculated from records of the Lacombe

duration of gndwtr. rec.	total pot. gndwtr. dis.		actual gndwtr. discharge		% of tot. fl.	remaining pot. gndwtr. dis.		total recharge	ch. in storage
	acre-ft.	inches	acre-ft.	inches	%	acre-ft.	inches	inches	inches
July 7, 1916 to Sept. 5, 1916	41000	1.08	28300	0.75	23	12700	0.33		
Sept. 7, 1916 to Dec. 10, 1916	33600	0.89	28150	0.74	51	5450	0.15	0.56	-0.19
April 13, 1917 to Aug. 31, 1917	46700	1.23	42910	1.13	37	3790	0.10	1.08	+0.34
Oct. 19, 1917 to Dec. 23, 1917	6900	0.18	4700	0.12	51	2300	0.05	0.08	-1.05
April 13, 1918 to Aug. 23, 1918	14860	0.39	13500	0.36	44	1360	0.03	0.34	+0.21
Sept. 30, 1918 to Nov. 22, 1918	2890	0.08	1840	0.05	67	1050	0.03	0.05	-0.31
April 2, 1919 to Sept. 9, 1919	15550	0.41	14430	0.38	40	1120	0.03	0.38	+0.33
Sept. 11, 1919 to Feb. 28, 1920	4580	0.12	4280	0.11	53	300	0.01	0.09	-0.29
April 15, 1920 to Sept. 7, 1920	30400	0.80	29730	0.78	15	670	0.02	0.79	+0.68
Sept. 12, 1920 to Dec. 2, 1920	3590	0.09	2590	0.07	58	1000	0.02	0.07	-0.71
April 19, 1921 to Jan. 20, 1922	12330	0.33	12160	0.32	36	170	0.01	0.31	+0.24
April 30, 1922 to Dec. 4, 1922	5260	0.14	5150	0.13	47	110	0.01	0.13	-0.19
			total:	4.94	ave. 30		total:	3.88	total -0.94
			ann. ave	0.58			ave:	0.32	
			ave/recession	0.41					ave. -0.09

FIGURE 5. ANALYSIS OF STREAMFLOW RECORDS

Experimental Farm from 1921 to 1956, is an annual average increase of 0.03 inches. Average soil thickness is assumed to be four inches. The change in surface water storage is based on lake level measurements taken at Gull Lake from 1924 to 1962. Changes in level of other, smaller lakes were ignored, probably being negligible in volume compared to those of Gull Lake. During the 39 years of record, Gull Lake declined an average of 0.20 feet, or 2.4 inches annually. Expressed as inches of decline over the entire basin, not just the lake itself, this would be 0.11 inches annually. Underground flow to or from neighboring basins is impossible to measure, but is assumed to be nil because of the topographic characteristics of the basin (Toth, 1962). Figure 6 illustrates Toth's theoretical analysis as applied to an actual profile across the Blindman River Valley, assuming no underground flow from outside the basin. Annual evapotranspiration is 15.64 inches, this value being obtained by balancing equation (6) for all other values first. Although several methods of measuring and calculating evapotranspiration exist, there is as yet little agreement as to their actual validity.

GROUNDWATER IN THE PASKAPOO FORMATION

GENERAL STATEMENT: The Paskapoo Formation contains fairly porous sandstone aquifers and is one of the best bedrock sources of groundwater in Alberta. Shale aquifuges in the formation will not be considered further. Sandstones in the formation are highly variable; some are poorly indurated and friable, whereas others are highly calcareous and very hard. Grain size ranges from very fine to coarse sand.

The Paskapoo Formation is the principal source of groundwater in the Blindman River valley. Most bedrock wells have a considerable hydrostatic pressure, and many flow, especially in topographically low areas (Figure 10).

To the present time, the formation has been able to meet all municipal and industrial needs for water.

PERMEABILITY: The permeability of a formation is its ability to transmit fluid through its pores when the fluid subjected to a difference in head. The coefficient of transmissibility is the product of permeability times the saturated thickness of the aquifer and is a very useful parameter for evaluating the capacities of wells. True transmissibility and the apparent transmissibility computed from the results of driller's pump tests are defined and contrasted in Appendix B. Apparent transmissibility is usually less than true transmissibility, because of well loss, or removal of water directly from the well bore rather than from the aquifer during the initial part of a pump test.

NATURE OF SANDSTONE AQUIFERS: Sandstone aquifers in the Paskapoo Formation are irregular lenticular bodies, probably because of their mode of deposition. Only the major sandstones could be illustrated in Figures 9A and 9B, as many minor sandstones were less than a mile in lateral extent. These sandstone bodies appear to be disconnected, but sufficient permeability must be present in the intervening material to allow recharge as they are depleted by pumping. Because of irregularity of the aquifers, it is impossible to predict the depth at which water will be obtained. However, because of the number of sandstone aquifers present, very few wells are deeper than 200 feet.

WATER LEVELS: As a general rule, nonpumping levels in wells of this area reflect the surface topography. Farvolden (1961, p. 13) has assumed that this is a result of local recharge from precipitation.

In the Pembina oil field, Farvolden (1961, p. 13) found that deeper

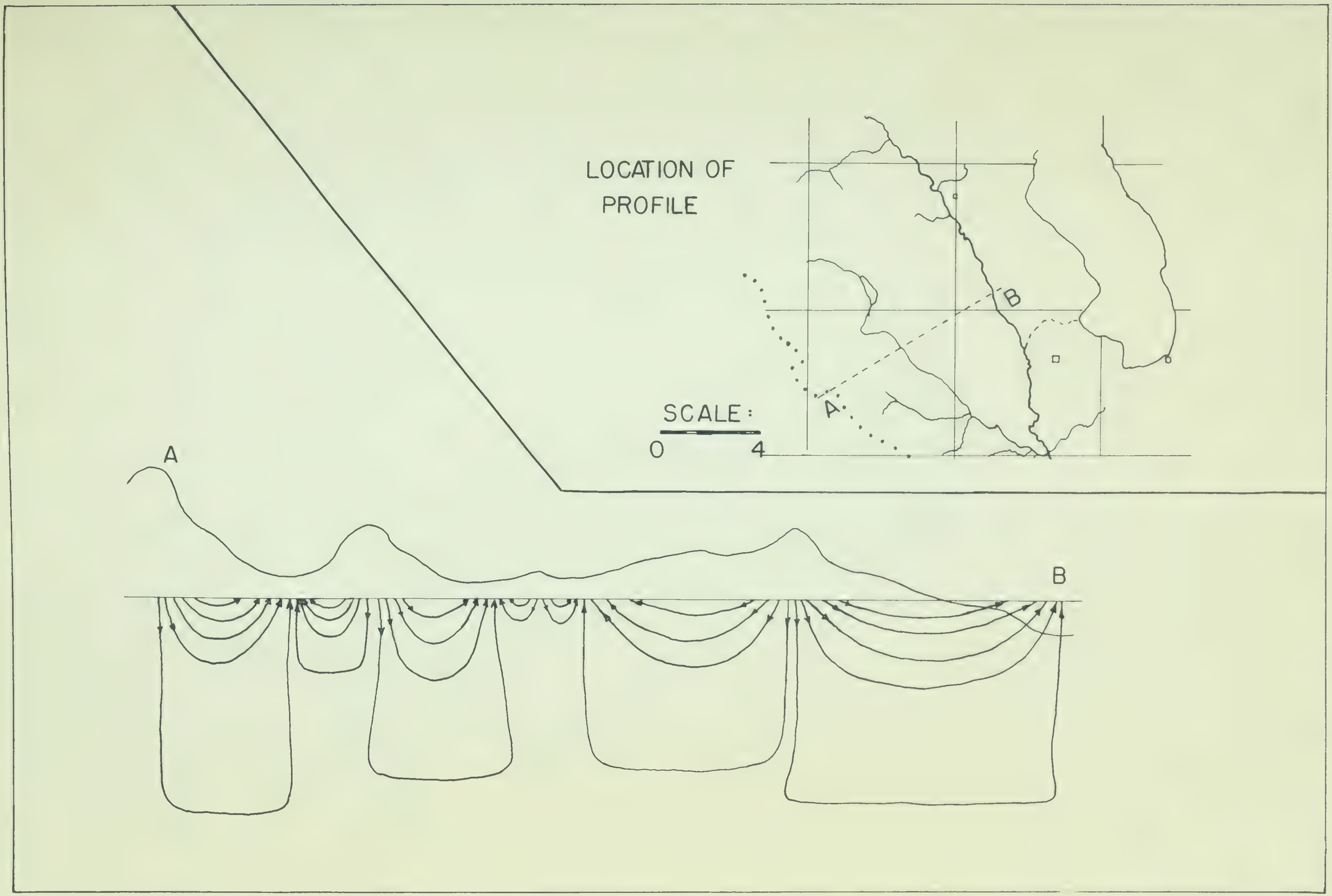


FIGURE 6.

PROFILE OF GROUNDWATER FLOW LINES IN THE BLINDMAN RIVER BASIN

FIGURE 7. APPARENT TRANSMISSIBILITY OF THE PASKAPOO FORMATION
BLINDMAN RIVER BASIN

wells were necessary in high areas than in low areas. In low areas, the deeper a well is drilled, the higher its nonpumping level becomes. These observations appear to apply to the Blindman River valley as well. For example, all the bedrock wells drilled in the Gull Lake Channel at the north end of the lake are flowing wells.

Because many of the aquifers are relatively thin, wells frequently penetrate more than one in order to obtain a sufficient amount of water. One result of this multiaquifer development (discussed by Meyboom, 1961a, p. 27) is that water flows from an aquifer of greater artesian pressure (usually the highest) to one of lesser pressure. The seismic surveys conducted in the Rimbey area have provided an interesting aspect to this type of development. Many farmers have complained that seismic shooting has "destroyed the water vein." It is more likely that the shotholes drain water from the uppermost aquifers to lower ones. If a farm well only penetrates the highest aquifer, its nonpumping level might drop. The filling of shotholes with concrete is usually necessary to correct this situation. Because of the cost involved, most shotholes are not filled in, but only capped.

Figure 18 shows the elevation to which water will rise in wells penetrating the bedrock. This is not termed a piezometric surface map, inasmuch as a piezometric surface is the result of varying artesian pressure within a single aquifer. This map is based upon water level observations in wells completed in the most commonly used aquifers in any general area. The few abnormal values were discarded..

CHEMICAL COMPOSITION OF GROUNDWATER: Groundwater from the Paskapoo Formation in the Blindman River valley is similar in composition to that from the same formation in other areas (Le Breton and Jones, 1962) Most ions, however,

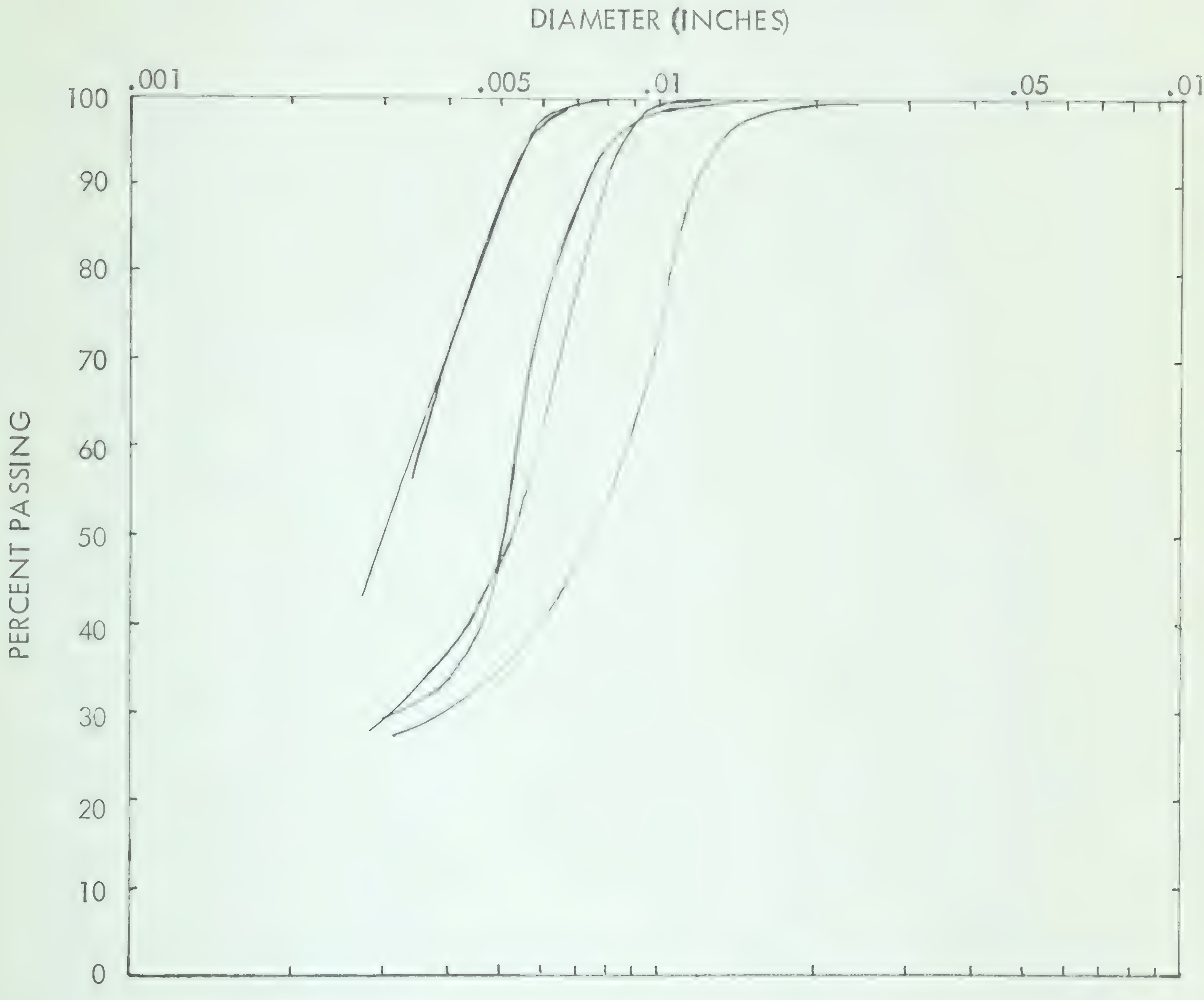


FIGURE 8. SIZE ANALYSES OF TYPICAL PASKAPOO SANDSTONES

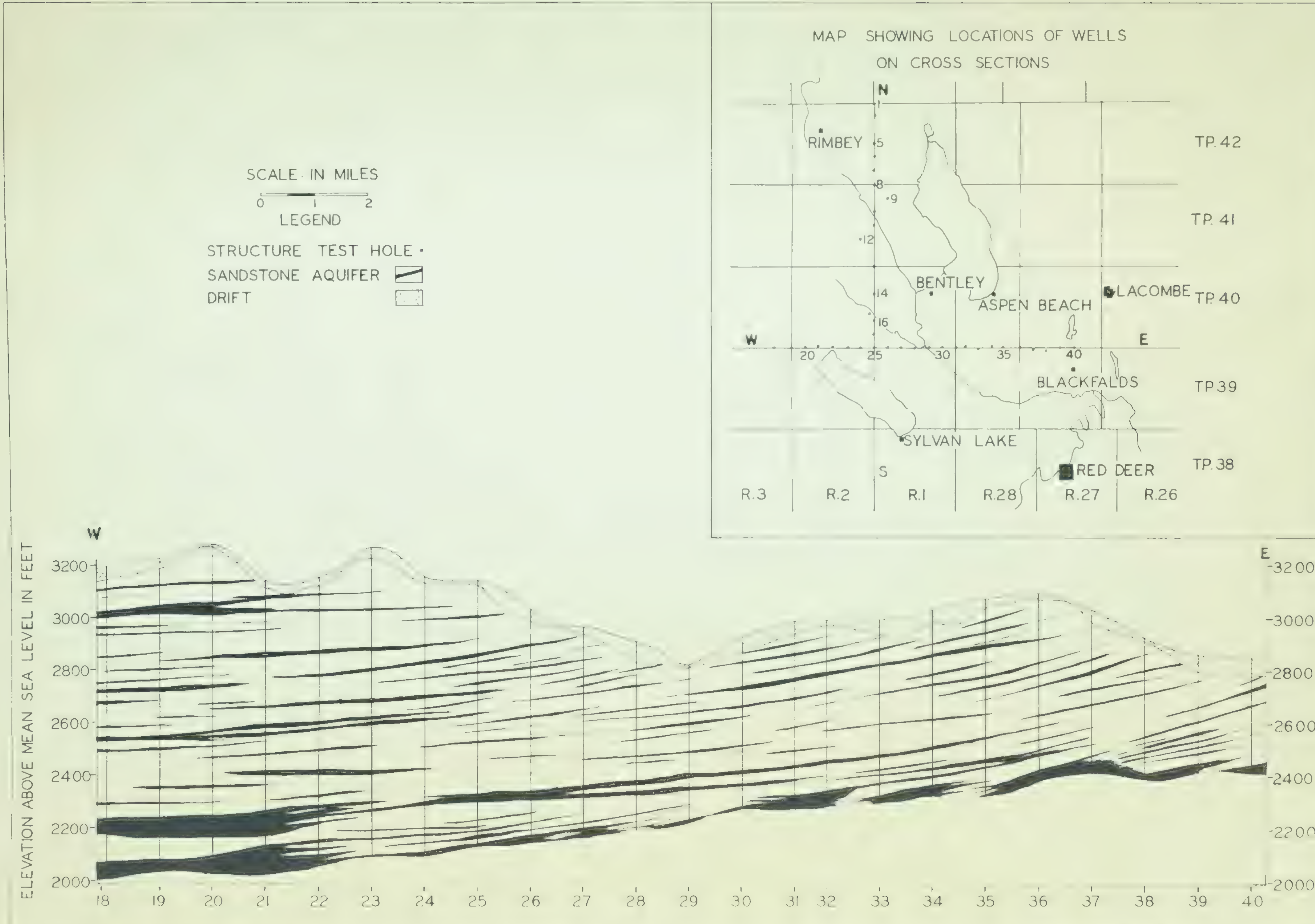


FIGURE 9A. NATURE OF SANDSTONE AQUIFERS WITHIN THE PASKAPOO FORMATION
EAST-WEST CROSS SECTION

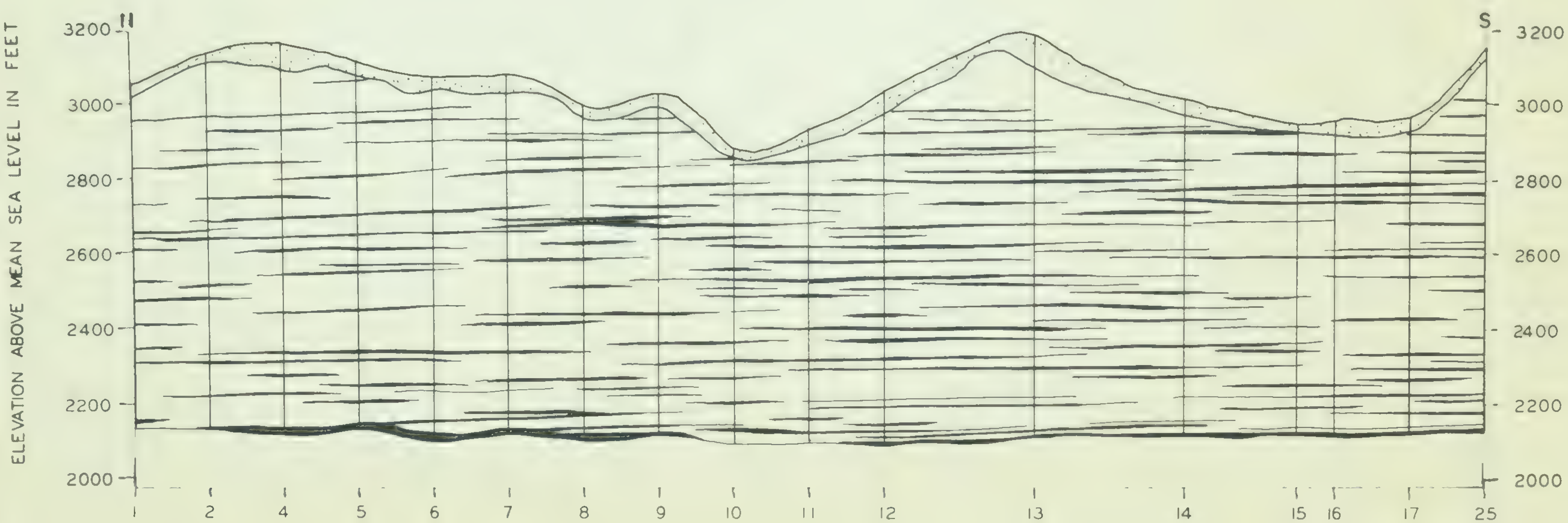


FIGURE 9B NATURE OF THE SANDSTONE AQUIFERS WITHIN THE PASKAPOO FORMATION

NORTH - SOUTH CROSS SECTION

show a greater range of values, perhaps because the study involves a complete basin with water in all stages of the flow system.

Variations of chemical composition in the basin have been mapped for total solids, hardness, sulphates, and iron content in Figures 12A, 12B, 12C, and 12D. Ignition loss was not mapped because it is of little significance, except as a means of detecting organic contamination (Hem, 1959, p. 50), and nitrites and nitrates are almost absent except in contaminated water. Chlorides and alkalinity were not mapped because the range of values was too low to warrant contouring. Furthermore, alkalinity is reported as bicarbonate of calcium, magnesium, and sodium, and is partly reflected in the hardness map.

Those chemical constituents of groundwater normally analysed by the Provincial Analyst of Alberta will be discussed in the same order as in his analyses. All values, unless otherwise stated, are in parts per million (ppm).

Total solids is defined as the remaining dry residue after complete evaporation. 500 ppm is the upper limit of first class U.S. Public Health standards. Their "acceptable" upper limit is 1000 ppm. The author found that 40% of the samples analysed met first class U.S. Public Health standards, and only one sample exceeded the "acceptable" upper limit. 98 per cent of samples analysed were "acceptable" on the basis of total solids.

Ignition Loss is the loss upon heating to a dull red. It will not be considered further.

Hardness is the amount of calcium, magnesium, and sodium carbonate and bicarbonate in water. Carbonates are relatively unimportant quantitatively because of their insolubility in concentrations greater than 10 ppm. Calcium, magnesium, and sodium bicarbonate ions are responsible for most of the hardness values.

Although several sets of limits are in use for defining the hardness

FIGURE 10. FLOWING WELLS AND SPRINGS IN THE BLINDMAN BASIN

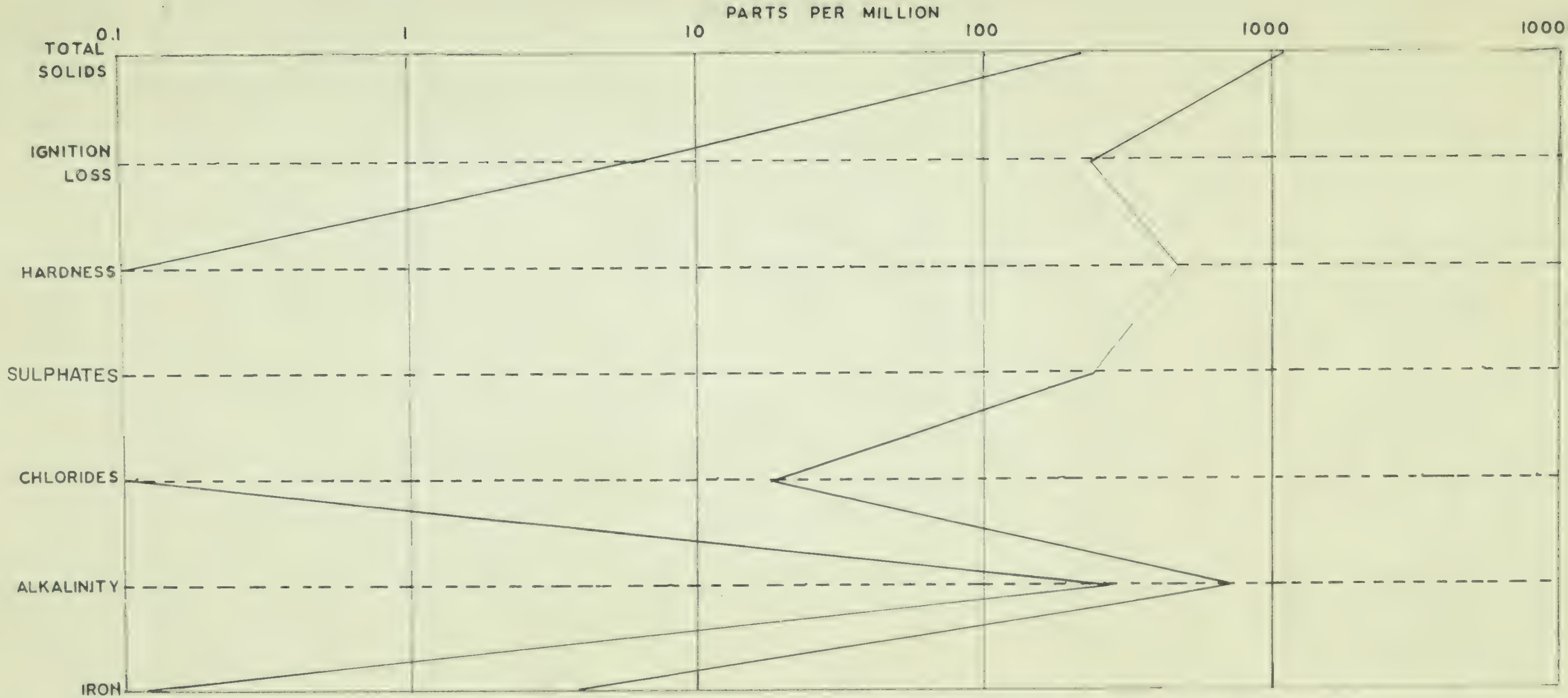


FIGURE 11. RANGE OF CHEMICAL COMPOSITION OF GROUNDWATER FROM THE PASKAPOO FORMATION IN THE BLINDMAN RIVER BASIN

of water, the author prefers those used by the Research Council of Alberta (Le Breton, personal communication) in which water containing 0 to 100 ppm hardness is considered soft, 101 to 250 moderately hard, and greater than 250 hard. By this division, 54 per cent of samples were soft, 37 per cent were moderately hard, and 9 per cent were hard.

An interesting distribution of hardness values is shown in Figure 12 B. The hardest waters occur in the upper part of the basin and in the recharge areas away from the main streams. The softest waters are those in the discharge areas along the main streams and in the southeast part of the basin.

Water entering the bedrock contains large amounts of calcium and magnesium ions derived from the overlying till, and is relatively hard. As the water flows through the bedrock toward stream valleys, it encounters bentonitic beds in which calcium and magnesium ions are removed from the water and replaced by sodium ions, thus making the water softer. Because of this, water from discharge areas is generally soft. Six analysed waters were of sodium bicarbonate type and these, with one exception, were from lowland discharge areas. Most waters containing only calcium and magnesium bicarbonate hardness were in recharge areas. The majority of waters however, contained all three ions. Because the Paskapoo Formation contains only bentonitic shale, and little pure bentonite, the softening effect is probably less pronounced than in formations which are more highly bentonitic.

Sulphates (Hem, 1959, pp.100-102) in water from the Paskapoo Formation have two probable sources: the solution of pyrite found commonly in shale, and hydrogen sulphide in natural gas.

250 ppm is the upper acceptable limit of sulphates for U.S. Public Health standards. All bedrock groundwater analyses were well below this figure.

The sulphates map (Figure 12 C) resembles the total solids map (Figure

FIGURE 12 A. GROUNDWATER CHEMISTRY OF THE PASKAPOO FORMATION
TOTAL SOLIDS

12 A) in the distribution of areas of high and low values. This similarity was noted for all of Alberta by Le Breton and Jones (1962, p. 14), but only for surficial deposits. They felt that waters from areas of high precipitation and highly permeable aquifers tend to be high in both sulphates and total solids. These reasons are probably not entirely valid for bedrock aquifers in the Blindman River basin, however. There is too little variation in precipitation and aquifer permeability within short distances to explain the rapid changes of sulphate concentration. It appears more likely that high concentratious of sulphate salts cause higher values of total solids, thus explaining the similarity of the two maps.

Chlorides (Hem, 1959, pp. 103, 104) are present in small quantities in all analyses, with the greatest concentration being 18 ppm. The principal source of chlorides in groundwater is sodium chloride and domestic sewage. The almost complete lack of chloride ions therefore indicates little or no salt water contamination, and no problem of pollution from sewage.

Alkalinity (Hem, 1959, pp.92-97) is defined as the ability of water to neutralize acid. Alkalinity of a sample may change between time of collection and time of analysis, thus values given in water analyses are somewhat questionable. Concentrations greater than 500 ppm if of sodium type corrode aluminum and may harm plants. Only eight per cent of the samples exceeded this value, and none were above the upper safe limit of 750 ppm.

Sources of iron in groundwater are iron oxide, iron carbonate, and iron hydroxide cements and dark ferromagnesian minerals in the bedrock (Hem, 1959, pp.58-66). Rusted well casings and pump parts frequently cause a well water sample to be higher in iron content than the water in the aquifer. Concentrations greater than 0.3 ppm may cause staining of clothes and will promote the growth of iron bacteria. In some areas, concentrations up to 10 ppm are

FIGURE 14 B GROUNDWATER CHEMISTRY OF THE PASKAPOO FORMATION

HARDNESS

common. In the Blindman River valley, 71 per cent of all samples exceeded 0.3 ppm, with a maximum concentration of 3.5 ppm.

Fluorine content is analyzed only upon specific request, and hence too few analyses are available to warrant discussion. It is worth noting however that the few analyses available show concentrations not exceeding about 2.0 ppm. One to two ppm appears to be a safe and effective concentration to promote dental health (Dr. G. C. Sabey, Dentist, Calgary, personal communication).

In order to study properly the variations of groundwater chemistry in an area of this size, many more analyses are needed. So far as possible, samples should be taken from wells at about the same depth and in constant use. Those from wells that are only occasional use may give misleading values for iron. Only in this way can different analyses be compared properly. Such an ideal situation was not obtained in this study, but sufficient information was available, to show chemical trends.

GROUNDWATER IN THE SURFICIAL DEPOSITS

GENERAL STATEMENT: Surficial deposits at present constitute only a minor source of groundwater in the Blindman River valley. Many older farm wells penetrating only the surficial deposits are being replaced by deeper ones, which are less subject to contamination and depletion. Gravel and sand are the major aquifers in the surficial deposits, other materials being too impervious to transmit water in appreciable quantities.

EXTENT OF SAND AND GRAVEL DEPOSITS: Figure 13 illustrates the areal extent of major sand and gravel occurrences, both exposed and buried beneath other materials. To some extent, the latter are not really unconfined, because overlying till acts as an aquiclude. In addition, minor sand and gravel lenses

FIGURE 12C GROUNDWATER CHEMISTRY OF THE PASKAPOO FORMATION

SULPHATES

FIGURE 12D. GROUNDWATER CHEMISTRY OF THE PASKAPOO FORMATION
IRON CONTENT

occur irregularly throughout the till, and these may yield sufficient water for a modest farm supply. Locating these aquifers is largely a matter of luck. Figure 13 was based upon Alberta Soil Survey maps (1947, 1960, in preparation), the Surficial Geology map by Stalker (1960), and seismic shot hole records, and includes buried sand and gravel, as well as surface occurrences.

The preglacial Red Deer Channel is the best potential groundwater source in surficial deposits in the map area. In the Blindman River basin, only one well, located one-half mile south of Blackfalds, is known to penetrate this channel. It encountered 70 feet of gravel without reaching bedrock. Its potential pumping rate has not been established, but it was tested at 10 gallons per minute with no measurable drawdown.

Appendix E contains a list of known locations of thick gravel and sand deposits which could be drilled for groundwater development, or could be utilized for the sand and gravel.

CHEMICAL COMPOSITION OF GROUNDWATER: Although too few analyses are available to discuss statistically, the following general statements can be made about the chemical properties of groundwater from surficial deposits. Except for chlorides, water from surficial deposits has a narrower range of values than that from the bedrock (Compare Figures 11 and 14), but this may be because fewer samples were analysed. All constituents except iron and total alkalinity are present in higher concentrations than from bedrock water.

Maximum concentration of total solids is 1170 ppm, a little above the acceptable upper limit of U.S. Health standards (1000 ppm), but considered only moderately high for Alberta by Mr. Noble, the Provincial Analyst.

Ignition loss and hardness are somewhat higher than for bedrock water.

Concentration of sulphates reaches an upper limit of slightly more than

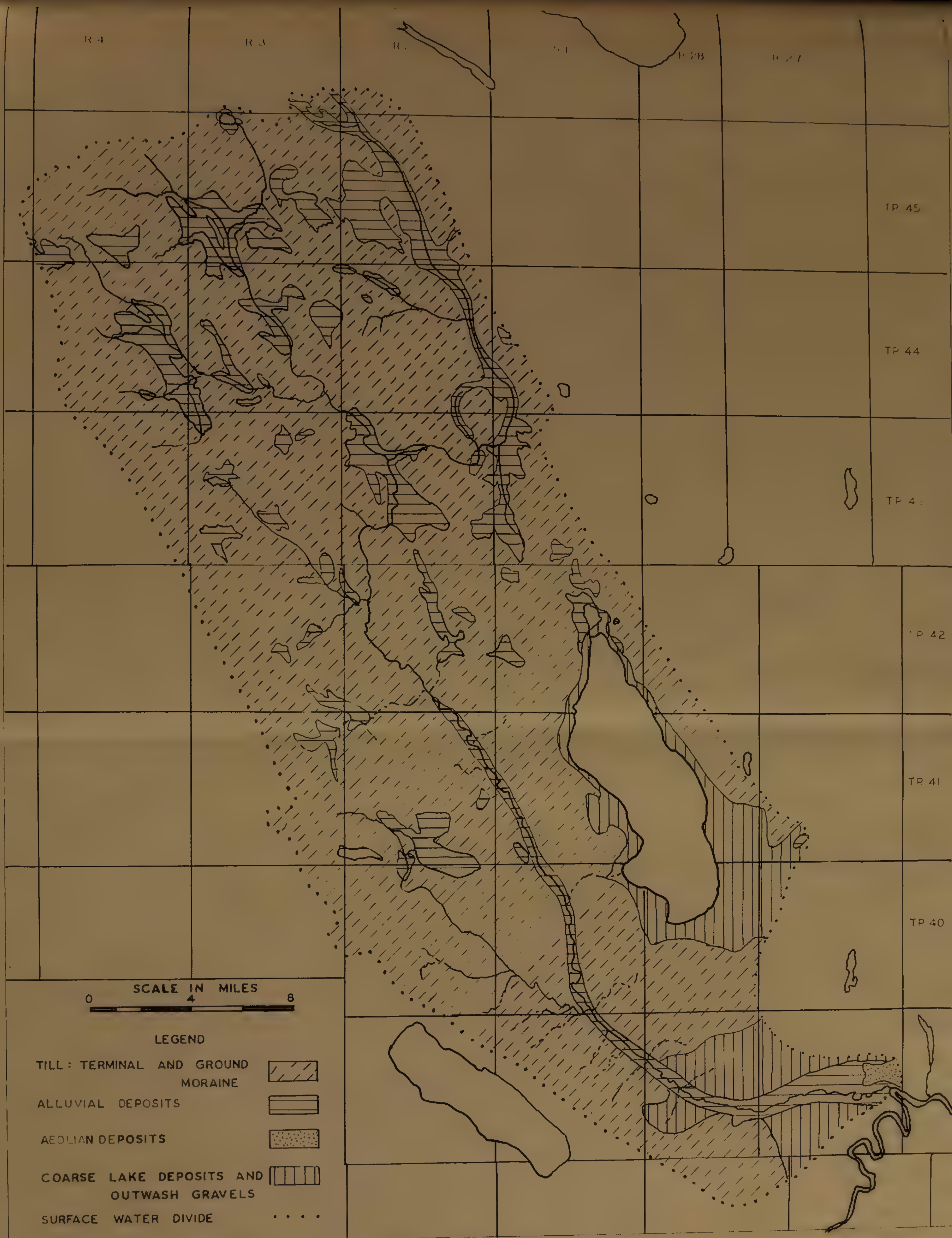


FIGURE 13. SURFICIAL DEPOSITS OF THE BLINDMAN RIVER BASIN

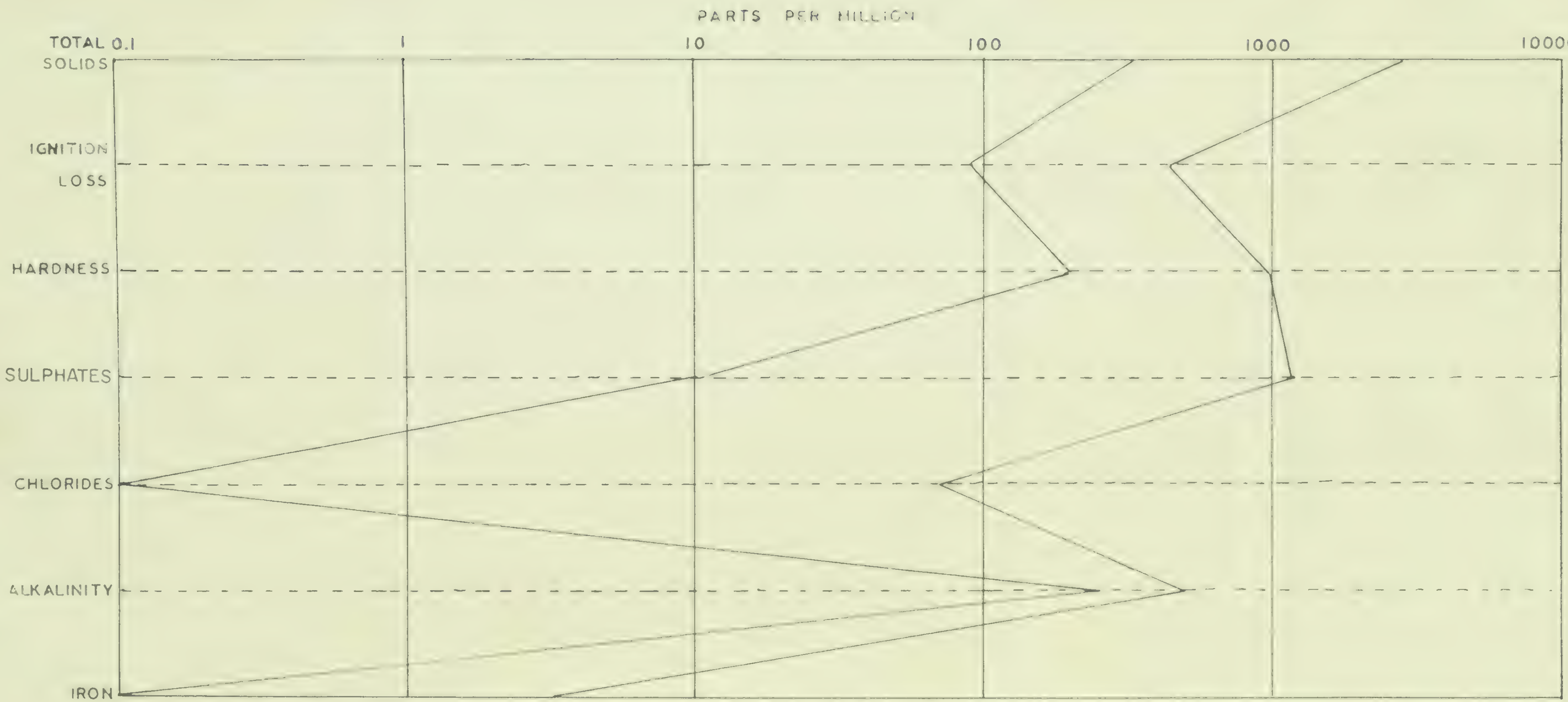


FIGURE 14. RANGE OF CHEMICAL COMPOSITION OF GROUNDWATER FROM SURFICIAL DEPOSITS IN THE BLINDMAN RIVER BASIN

1000 ppm, which is far too high for human use, and may indicate gypsiferous material in the surficial deposits.

Chloride content is also higher than in bedrock water and may be derived from evaporites in the till.

Alkalinity is almost entirely of calcium and magnesium types in surficial deposits.

ECONOMIC GEOLOGY OF GROUNDWATER

GENERAL STATEMENT

As indicated in the foregoing pages, the Blindman River valley has ample groundwater resources. The water is of good quality and occurs at reasonable depths. The following discussion will demonstrate the extent to which these resources are being utilized, and indicate possible future development.

TOWN AND VILLAGE SUPPLIES

ASPEN BEACH PROVINCIAL PARK: Most wells at Aspen Beach have been drilled into the Paskapoo Formation and average about 100 feet in depth. Each home has its own well, and in addition, the provincial park has six. These latter yielded sufficient water for an estimated 400,000 visitors during the summer of 1961. One of these, drilled in July, 1955, is 103 feet deep, with a nonpumping level five feet below the surface. Apparent transmissibility is about 4000 gallons per day per foot. The driller recorded the following lithologic log:

0-5 feet	fine sand
5-15	brown sandstone
15-103	blue shale

The following chemical analysis is of water from a cottage well at the east end of Aspen Beach:

Total Solids -	538 ppm	Nature of Alkalinity: Bicarbonate of calcium and magnesium
Ignition Loss -	116 ppm	
Hardness -	375 ppm	Nitrites - 0 ppm
Sulphates -	122 ppm	Nitrates - 0 ppm
Chlorides	2 ppm	Iron - 0.2 ppm

Alkalinity - 360 ppm

BENTLEY: Bentley, with a population of about 500, has no village water system, and none is planned for the immediate future. Each house and business has its own well, most of which are drilled to a bedrock aquifer at about 2900 feet elevation, and are 85 to 105 feet deep, depending on surface elevation. Some of the newer wells, such as those at the new creamery and at the Marshall Wells store have been drilled to a lower bedrock aquifer at about 2820 feet elevation. Both aquifers yield moderately soft water. The log of the new creamery well, drilled in 1961 is as follows:

0 - 35 feet	sandy and stones
35-75	clay
75-85	sandstone
85-95	shale
95-105	sandstone
105-168	soft shale
168-180	shale
180-181	soft shale

Water from the Marshall Wells store was analyzed thus:

Total Solids	344 ppm	Nature of Alkalinity:	Bicarbonate
Ignition Loss -	120 ppm	of sodium, calcium, and magnesium	
Hardness	230 ppm		
Sulphates -	0 ppm	Nitrites -	trace
Chlorides -	trace	Nitrates -	trace
Alkalinity -	315 ppm	Iron -	2.0 ppm

BLACKFALDS: The village of Blackfalds has two wells, plus a school well, serving about 450 people. Only one well, at the firehall, is used at present,

the other two being kept on reserve. All three were drilled into sandstone aquifers of the Paskapoo Formation. The firehall well was pump-tested on July 17, 1962, and found to have a true transmissibility of 1725 gallons per day per foot. Its maximum safe yield is 30 gallons per minute. The aquifer used by both the school well and the firehall well occurs at an elevation of 2730 feet. All three wells are about 200 feet deep. Analyses of water from these latter two wells are quite similar:

	School Well	Firehall Well
Total Solids	580 ppm	542 ppm
Ignition Loss	20 ppm	42 ppm
Hardness	20 ppm	10 ppm
Sulphates	23 ppm	0 ppm
Chlorides	3 ppm	0 ppm
Alkalinity	495 ppm	495 ppm
Nature of Alkalinity: Bicarbonate of -	Sodium, Calcium and Magnesium	Sodium

The main difference between these analyses are in the concentration of sulphates, and the nature of alkalinity. Blackfalds is situated near the edge of the preglacial Red Deer River Channel, and perhaps water in the school well percolated down through a sulphate rich stratum which had been eroded by the preglacial river nearer the firehall. Unfortunately, no lithologic logs are available to substantiate this hypothesis.

Present supplies of water appear sufficient for immediate anticipated growth of the village. Should supplies later prove insufficient, wells could be drilled into the Red Deer River Channel.

BLUFFTON: There is at present no village water supply at Bluffton. Most wells are less than 100 feet deep, and are drilled to a bedrock aquifer at 2060 feet elevation. Water in these wells is hard, but another aquifer 15 feet lower carries soft water.

The school well, about one-half mile north of the village, is located in the river valley, and was drilled through the following rock types:

0 - 28 Feet	clay and boulders
28 - 30	sandstone
30 - 62	soft sandstone
62 - 101	shale
101 - 104	sandstone
104 - 139	shale
139 - 140	sandstone
140 - 142	shale

The well was bailed for two hours and flushed, and cased with 113 feet of $4\frac{1}{2}$ inch steel casing. Its water was analysed as follows:

Total Solids	-460 ppm
Ignition Loss	- 34 ppm
Hardness	- 10 ppm
Sulphates	- 18 ppm
Chlorides	- 17 ppm
Alkalinity	-350 ppm
Nature of Alkalinity	- Bicarbonate of sodium
Nitrites	- 0 ppm
Nitrates	- 0 ppm
Iron	-0.8 ppm
Soda	-25.2 grains per gallon

FORSHEE: Two bedrock aquifers are in use at Forshee, one at 25 feet depth, and the other at 40 feet depth. The upper yields hard water, and only in small amounts, whereas the lower provides a larger quantity of softer water.

HOADLEY: At least two bedrock aquifers are in use at Hoadley: one 80 feet deep, and one 120 feet deep. Water in this area is very hard. Most drilled wells are about 100 feet deep. Some shallow dug wells are used because they are less expensive, but these are inferior in both quality and reliability.

RIMBEY: The town of Rimbey, with a population of 1300, is experiencing a rapid population growth and a rapidly increasing demand for water. From 1959 to 1961, water consumption increased by 21 per cent.

International Water Supply made a study of water needs and resources for the town in 1950. At that time, at least 30 gallons per minute were required. Town Well Number 1 was subsequently drilled in the school grounds to a depth of 203 feet. This well has an apparent transmissibility of 4100 gallons per day per foot and can be pumped at 58 gallons per minute. Its nonpumping level is 142 feet below ground level. Two 8 inch by 5 feet iron screens were installed, and the well was gravel packed from 193 feet to 202 feet. This well, like the other three town wells, was drilled into the Paskapoo Formation.

Town Well Number 2 was drilled at the corner of Queens Avenue and Main Street to a depth of 202 feet. Its nonpumping level is 104 feet below ground level, and aquifers are present at depths of 52 feet, 119 feet, and 168 feet. The apparent transmissibility of this well is 1300 gallons per day per foot, and is pumped at 20 gallons per minute. From the information available, no screens nor gravel pack appear to have been used.

In 1958, Town Well Number 3 was drilled to 205 feet, but later deepened to 304 feet. Aquifers were found at 90 feet, 165 feet, and 195 feet. The

uppermost contained hard water and was cased off. Since this well yields only about 15 gallons per minute, it is not used at the present time. Steel casing, 8 5/8 inches in diameter was set to 82 feet, and 6 5/8 inches in diameter from 82 to 125 feet.

In 1960, after a critical water shortage had developed, the Research Council of Alberta investigated and tested the bedrock aquifers underlying the town.

The fourth town well was drilled in March, 1960 to a depth of 325 feet. It has a true transmissibility of 3820 gallons per day per foot and is pumped at 58 gallons per minute. This well has an 8 inch steel casing driven to 56 feet below ground level. It is now the major town supply and is considered adequate for present needs. However, consumption is expected to rise by 270 per cent between 1960 and 1985. The Research Council of Alberta therefore suggested that as demand arose, wells should be drilled at the following locations:

1. Corner of Sifton Avenue and 2 Street East
2. 500 feet west of hospital on Jasper Avenue

Lithologic sections encountered by the four wells are as follows:

Number 1

0 - 1 foot	topsoil
1 - 31 feet	clay and gravel
31 - 104	clay, shale and pebbles
104 - 106	sandstone
106 - 141	grey shale
141 - 144	sandstone
144 - 164	shale

Number 2

0 - 42 feet	clay, some gravel
42 - 52	boulder clay
52 - 70	dark blue shale, with water
70 - 79	light grey shale
79 - 85	brown shale
85 - 93	grey shale
93 - 97	brown shale

164 - 166 feet	light grey shale
166 - 173	dark grey shale
173 - 175	light grey shale
175 - 188	dark grey shale
188 - 193	light grey sandstone
193 - 203	hard dark grey shale

Number 3

0 - 50 feet,	glacial clay and boulders
50 - 105	shale (must have a sand-stone lens at 90 feet)
105 - 117	sandy shale
117 - 165	sticky shale
165 - 178	sandstone, water
178 - 195	sticky shale
195 - 204	sandy shale, water
204 - 205	sticky shale
205 - 304	log not available

97 - 119 feet	grey shale
119 - 129	sandstone, water
129 - 168	grey shale
168 - 173	sandstone, water
173 - 202	grey shale

Number 4

0 - 1 foot	topsoil
1 - 16 feet	stony yellow clay
16 - 19	sandy clay
19 - 37	hard grey clay
37 - 38	sandstone
38 - 45	hard grey shale
45 - 99	blue shale
99 - 205	blue shale, water
205 - 218	sandy shale
218 - 223	hard blue shale
223 - 237	sandy shale
237 - 250	hard blue shale
250 - 259	sandy shale
259 - 264	sandy shale, sandstone
264 - 266	sandstone
266 - 287	sandy shale
287 - 302	hard blue shale
302 - 310	sandy shale
310 - 315	hard blue shale

Number 4

315 - 325 feet sandy shale

Analyses of water from these wells are as follows, in ppm:

	Number 1	Number 2	Number 3	Number 4
Total Solids	560	724	672	710
Ignition Loss	90	10	40	66
Hardness	154	0	10	0
Sulphates	40	140	66	79
Chlorides	2	1	13	3
Alkalinity	430	440	470	470
Nature of Alkalinity:				
Bicarbonate of	-	sodium	sodium, calcium, magnesium	sodium
Nitrites	0	0	0	0
Nitrates	0	0	0	0
Iron	0.7	-	0.5	0.2
Fluorides	0.3	-	1.0	0.6
Soda (in grains per gallon)	-	32	34.13	34.9

Wells number 2 and 4 have only sodium hardness, whereas number 3 has sodium, calcium, and magnesium hardness. The reason for these differences is not apparent, although different wells tap different aquifers.

INDUSTRIAL SUPPLIES

BENTLEY OIL FIELD: In 1958, the Oil and Gas Conservation Board of Alberta conducted a survey of water wells in the Bentley area to aid in establishing a waterflood system for the Bentley Oil Field (now the eastern part of the Gilby field). Shortly thereafter, seven water supply wells were drilled,

each 100 feet from an injection well. These were in three rows, as follows (locations are listed in the following order: Legal subdivision, Section, Township, Range, West of the Fifth Meridian):

East Row	Centre Row	West Row
14-2-40-1-W.5	6-16-40-1-W.5	6-19-40-1-W.5
2-11-40-1-W.5	10-16-40-1-W.5	10-19-40-1-W.5
	11-16-40-1-W.5	

Well 14-2-40-1-W.5 was later shut in because of well bore damage, and replaced by A2-11-40-1-W.5.

Information is not available on all these wells, but well 14-2 is 732 feet deep, and 6-16 is 801 feet deep. Both penetrate aquifers in the basal Paskapoo Formation. To fulfill Conservation Board requirements, all were drilled at least 50 feet deeper than the lowest aquifer already in use (Appendix A).

The only data available on the chemistry of water from these wells is a summary indicating a two-fold division of properties. Water from the East and Centre Rows has the following characteristics:

1. pH of 8.8 and high alkalinity due to the presence of sodium carbonate and sodium bicarbonate
2. No detectable sulphates
3. Fairly high chloride content - about 60 ppm
4. Extreme softness
5. High Turbidity and high iron content, due to presence of colloidal bentonitic clay.

Water from the West Row is from a different aquifer and is characterized by:

1. High chloride content, about 180 ppm

2. Low alkalinity, about one-half as great as that in the East and Centre Rows
3. Turbidity (about 3 ppm) from montmorillinite clay.

During the last two years, the rate of pumping totalled for all seven wells, has been gradually decreasing, due to a decline in well effeciency.

3rd quarter, 1959 - 179 gallons per minute

4th quarter, 1959 - 228 gallons per minute

2nd quarter, 1960 - 146 gallons per minute

3rd quarter, 1961 - 141 gallons per minute

1st quarter, 1962 - 113 gallons per minute

3rd quarter, 1962 - 120 gallons per minute

4th quarter, 1962 - 110 gallons per minute

In most wells, steel casing was set and the bottom 200 to 300 feet was slotted. Peerless Hi-lift pumps with electric motors were installed. Well 14-2-40-1-W.5 was drilled to 354 feet with a rotary rig, and 9 5/8 inch casing set to 285 feet. From 354 feet to 732 feet (total depth), drilling was done by a cable tool rig. From 285 feet to 655 feet, 7 inch, 23 pound, J-55 casing was set. A 5½ inch slotted casing was set from 635 feet to total depth.

Sand in the water has caused excessive abrasion of pumps and pipes, and high turbidity has also been a problem. Several wells are improved by bailing and jetting, but abrasion still continued to some extent. Desanders were later installed and appear to have solved the problem. No doubt much of this difficulty would have been avoided by analysing the size of the sand particles in the aquifers and installing screens with slots just finer than the sand size. Well efficiency would also be greater.

DICK LAKE GAS PLANT: The Dick Lake Gas Plant is located in SE-5-44-1-W.5. In 1962, it had three water supply wells, and was using about 150 gallons per

minute of water. A considerable expansion of the plant is planned, and an additional 500 gallons per minute will be required.

Well Number 1, located in legal subdivision 2, is 220 feet deep, with a 12 3/4 inch casing cemented to 117 feet, and a 6 5/8 inch casing and screens to total depth. The screens, Johnson Everdur with 0.02 inch slots, are set at three intervals: 172 to 182 feet, 198 to 206 feet, and 210 to 214 feet. The lower casing and screened sections were packed with a three inch layer of number 63.30 stabilizer material around the casing. On completion, nonpumping level was 137 feet below the surface. A storage coefficient of 3×10^{-4}, a true transmissibility of 6000 gallons per day per foot and a specific capacity of 2.70 gallons per minute per foot of drawdown (after surging) were calculated. It was recommended that this well be pumped at less than 35 gallons per minute to avoid interference with Well Number 2. The consulting firm arrived at this figure by using the coefficients of storage and transmissibility and a curve based upon the Theis Non-Equilibrium Method, (Barnell, 1961, Figure 10). The test was started April 20, 1960 and was conducted for 39 hours at 47.7 gallons per minute, during which time a drawdown of 36 feet occurred. Well Number 2, used as an observation well, showed a decline of 3.08 in water level.

Well Number 2, in legal subdivision 2, is 194 feet deep, of which the top 61 feet is cemented and cased with a 12 3/4 inch casing. Below 61 feet, the casing and screens are 6 5/8 inches in diameter to total depth, the screens being set at 140 to 145 feet, 160 to 166 feet, and 173 to 188 feet. Johnson Everdur screens with 0.02 inch slots were used. From 61 feet to total depth, the screens and casing are set in a pack of 63.30 stabilizer material. Nonpumping level was at 132 feet. A true transmissibility of 6000 gallons per day per foot, a storage coefficient of 3×10^{-4}, and a specific capacity of 2.63 gallons per minute per foot of drawdown were calculated from a pump

test. This test was begun April 23, 1960 and lasted 25 hours. The pumping well had a drawdown of 19 feet at a pumping rate of 50 gallons per minute, and Well Number 1, 531 feet distant, used as an observation well, showed a drop in level of 2.90 feet. Maximum safe pumping rate was calculated to be 45 gallons per minute, in order to minimize interference with Well Number 1.

Well Number 3, in legal subdivision 5, has a total depth of 100 feet. The upper 33 feet were cemented and cased with a 16 inch diameter casing, below which an 8 5/8 inch casing and screens were set in a pack of 93.40 stabilizer material. The screens, Johnson Everdur with 0.03 inch slots, were set from 39 to 41 feet, 53 to 56 feet, 60 to 63 feet, 70 to 75 feet, 80 to 87 feet, and 91 to 96 feet. The nonpumping level was 17 feet below the surface. Specific capacity increased from 3.65 gallons per minute per foot of drawdown before surging, to 5.40 after surging. True transmissibility is 7200 gallons per day per foot. The storage coefficient could not be calculated since no observation well was used in pump tests. The first test was begun August 6, 1960 and lasted 14 hours, with a pumping rate of 98 gallons per minute. Total drawdown was 31.3 feet, and a pumping rate of not more than 100 gallons per minute was recommended for this well. No definite information is available on interference from Wells 1 and 2. In another test of Well 3, however, 60 gallons per minute were pumped from a stabilized level of 28.1 feet, or 11.1 feet below the nonpumping level. This is 14 per cent of maximum theoretical yield in an average artesian aquifer (Barnell, 1961, p. 9). Therefore:

$$Y\ max. = \frac{60\ GPM}{0.17} = 353\ GPM. \qquad (7)$$

and 100 gallons per minute is 28.3 per cent of the maximum theoretical yield. This yield should be developed with 24 per cent of the available drawdown.

79 X .24 = 19 feet of drawdown to be expected with a pumping rate of 100 gallons per minute. This calculated drawdown is somewhat less than that observed in the first pump test of the well, but further testing subsequent to selective surging indicates that 100 gallons per minute will draw down less than 19 feet, and cause little interference with the other two wells.

The lithology encountered by these wells is as follows:

Well Number 1

0 - 6 feet	sand and boulders
6 - 22	clay
22 - 46	grey shale
46 - 52	brown sandstone, soft with blue seams
52 - 55	sandstone, soft, lost circulation
55 - 61	sandstone, soft
61 - 62	hard blue sandstone
62 - 74	soft brown sandstone
74 - 86	hard blue sandstone
86 - 95	grey sandstone
95 - 96	sandstone
96 - 115	sandstone, no returns
115 - 139	blue shale
139 - 140	hard sandstone
140 - 149	fine grey sandstone
149 - 160	shale
160 - 163	blue shale
163 - 169	blue sandy shale
169 - 171	sandstone

Well Number 2

0 - 28 feet	clay and rocks
28 - 36	shale
36 - 37	sandstone
67 - 69	sandstone
69 - 78	shale
78 - 81	sandstone
81 - 96	shale
96 - 130	shale, small sandstone stringers
130 - 145	grey sandstone
145 - 160	grey shale
160 - 194	lost circulation, no returns

171 - 182 feet	shale, small sandstone stringers
182 - 194	grey sandstone
194 - 196	no returns, drilled like pebbles
196 - 203	sandstone
203 - 220	grey shale, poor circulation and returns.

Well Number 3

0 - 25 feet	clay and rocks
25- 46	shale with sandstone layers
46- 100	no returns

The water from these wells has been analysed on a different basis from that used by the Provincial Analyst. The results follow, in parts per million:

	Well 1	Well 2	Well 3
Dissolved Solids	580	625	495
Total Hardness	6	32	68
Calcium Hardness (as $CaCO_3$)	6	20	40
Magnesium Hardness (as $CaCO_3$)	0	12	28
Phenolphthalein Alkalinity (as $CaCO_3$)	38	22	18
Total Alkalinity (as $CaCO_3$)	435	450	395
Chlorides (as NaCL)	2	2	2
Sulphates (as Na_2SO_4)	130	160	86
pH	8.7	8.5	8.4
Silica	8.8	9.5	9.5

OTHER INDUSTRIAL SUPPLIES: In addition to these two major water consumers, several minor industries use groundwater supplies. Most towns and villages

have creameries or slaughter houses, and Golden Grove Foods in Bluffton manufactures macaroni and related products.

The processing of 1000 pounds of milk, cream, or butter requires from 90 to 200 gallons of water. Slaughtering and packing one hog requires about 90 gallons. (Thomas, 1953, p. 15). Before any such industries are established, it should be ascertained whether water is available in sufficient quantity.

AGRICULTURE USE

Most of the wells in the Blindman River valley are on farms, and are used to supply domestic and livestock needs. Most wells penetrating the bedrock are satisfactory, poor drilling and completion techniques probably being responsible for those which are not. Techniques outlined by Jones (1962, p. 57), ie., bailing, surging, acidizing, use of detergents, hydrofracturing, screening, or screening and sand or gravel packing, will greatly improve most farm wells. Although most farms need a relatively small supply, farm wells should nevertheless be developed as efficiently as is economically practical. Thus the life of the well will be materially lengthened, probably resulting in a net saving over the cost of the several poor wells which would be necessary in the life span of one good well. Moreover, should a large quantity of water be needed, a properly developed well is far more capable of supplying it.

RECREATIONAL USE

Gull Lake, about 33 square miles in area, is major summer resort of central Alberta. No perennial streams flow into or out of the lake. Until the 1920's, however, a stream called Gull Creek flowed from the southwest part of the lake into the Blindman River. Since 1924, when measurements were first taken, the level of the lake has dropped almost eight feet (Appendix F). This has seriously impaired recreational facilities and alarmed local residents. Because of the small drainage area involved, Allan (1942, p. 1) felt the

lake was fed mainly by springs and underground sources.

Several proposals have been advanced for stabilizing the level of the lake. It has been suggested (Don Bowman, Alberta Water Resources, Edmonton, 1962, personal communication) for example, that the northeast branch of the Blindman River be diverted south into the lake. This proposal has several disadvantages. Aside from considerations of cost, it is by no means certain that the river has sufficient discharge to bring about stabilization, as the northeast branch has never been gauged. Furthermore, the river water has a dirty brown color and a faint odor, and authorities are naturally reluctant to divert this water into a lake known for its clean clear water.

Another proposal would utilize groundwater to stabilize lake level. Seismic parties have drilled a large number of flowing wells (now capped) at the north end of Gull Lake. It has been suggested (Ibid.) that these be allowed to flow freely into the lake. Since 1924, the annual average decline in lake level is 0.20 feet. Assuming a present lake area of 33 square miles, the annual loss of volume is $33 \times 5280 \times 5280 \times 0.20 = 1.83 \times 10^8$ cubic feet, or 11.30×10^8 gallons. There are 5.26×10^5 minutes in a year, thus a total flow of $\frac{11.30 \times 10^8}{5.26 \times 10^5}$, or 2150 gallons per minute would require more than 400 flowing wells at 5 gallons per minute (probably optimistic), merely to stop lake level dropping, without attempting to raise it. This number of wells could not be drilled in the limited area of artesian flow without considerable interference of their cones of depression, causing artesian pressures to drop rapidly to the point where the wells would cease to flow. Therefore, it appears that, even by utilizing all available groundwater, such a scheme would do little to stop the lake level from dropping.

Lake level was much lower between 1898 and 1904 than it is present

(Allan, 1942, p. 2). Older residents recall harvesting hay from areas now under water. Perhaps, as Allan has suggested (1942, p. 3), the level will adjust itself in time by processes not yet understood. However, this possibility appears remote, as many of the major lakes of the Alberta plains appear to be drying up (Don Bowman, 1962, personal communication). Similar behaviour has been noted at Lake Wabamun, for example where the lake is both drying up and filling with sediment. (The Edmonton Journal, January 18, 1963, p. 16).

The average annual potential evaporation at Lacombe Experimental Farm, eight miles east of the lake is 18.86 inches, or 1.87 feet. This is probably close to annual evaporation from Gull Lake. If evaporation from the lake surface could be reduced by 0.20 feet annually, lake level would be stabilized. In Victoria state (Australia), and in Kenya, workers have successfully used cetyl alcohol (a compound harmless to plants and animals) and related compounds as a thin film on ponds, reducing evaporation up to 50 per cent (Dixey, 1956, pp. 131, 132). Larger scale experiments in 1956 reduced evaporation by at least 30 per cent on small lakes. A similar experiment on Gull Lake might provide a simple and inexpensive way to stabilize lake level.

CONCLUSIONS

Within the Blindman River valley, the Paskapoo Formation, of Tertiary age, is capable of producing up to 100 gallons per minute from individual wells. Groundwater from this source is of high quality and suitable for industrial purposes. The Paskapoo Formation is at present the only source of potable water being utilized in the area of investigation. However, evidence suggests that the preglacial Red Deer Channel southeast of Blackfalds could be developed into a major groundwater source.

Efficient development of these aquifers will require greater cooperation among drillers, industry, and government agencies. All development programs should be preceded by adequate testing and investigation. It may become necessary to install observation wells in areas where bedrock aquifers become intensely developed, and in the Red Deer Channel when it becomes developed as a groundwater source. These will aid in preventing the depletion of these aquifers.

Groundwater is only one of the several phases of the hydrologic cycle, and it should be studied, not in isolation, but in its proper relationship to the other phases of the cycle. The interrelated hydrologic factors can be better determined by conducting research on the basis of drainage basins, rather than map quadrangles.

GLOSSARY

Aeolian - formed or deposited through the action of wind.

Aquiclude - earth material which can absorb water but whose openings are so small that the rate of transmission is too slow for extraction by wells. (Butler, 1959, p. 68)

Aquifer - a body of earth material capable of transmitting water through its porous openings in sufficient quantity to be of use for water supply purposes. (Ibid.)

Aquifuge - a body of earth material which is impervious and nonabsorptive. (Ibid., p. 337)

Artesian groundwater - groundwater confined under an aquiclude or an aquifuge, so that water rises in a nonpumping well which penetrates it. (Ibid.)

Bank Storage - water that is stored in the banks along a stream during high river stage, and that is released as the stage falls. (Kunkle, 1962, p. 1544)

Baseflow - stream discharge derived from effluent groundwater seepage. (Butler, 1959, p. 337)

Cone of depression - the area in which there is measurable drawdown due to pumping of a well. (Ibid., p. 117)

Confined (artesian) aquifer - an aquifer below an aquiclude or aquifuge, whose water exerts a positive pressure. (Ibid., p. 338)

Confining bed - a bed of earth material which is relatively impermeable, an aquiclude.

Drawdown - a lowering of the water surface or piezometric surface caused by pumping. (Ibid.,)

Effluent stream - a stream that receives water from the zone of saturation.

(Meinzer, 1923, p. 56)

Evapotranspiration - evaporation plus transpiration. (Butler, 1959, p. 339)

Groundwater - the general subsurface water body in the zone of saturation. (Ibid.)

Hydrology - the study of the characteristics and occurrences of water, and of the hydrologic cycle. (Ibid.)

Influent stream - a stream that contributes water to the zone of saturation. (Meinzer, 1923, p. 56)

Interference - occurs when the cones of influence (or depression) of two or more wells come in contact with one another, thereby decreasing the specific capacities of the wells. (Ibid. p. 63)

Interflow - water which infiltrates the soil surface and moves laterally through the upper soil layers to a stream channel. (Linsley, Kohler, and Paulhus, 1958, p. 150)

Intermittent stream - a stream that only flows at certain times, whether because of fluctuations of the water table above or below stream channels, or because of receiving water for protracted periods from a surface source. (Meinzer, 1923, pp. 57, 58)

Observation well - a nonpumping well in which drawdown caused by the pumping of a nearby well is measured.

Perennial stream - a stream that flows continuously, generally fed in part by springs, its upper surface generally stands lower than the water table in the localities in which it flows. (Ibid., p. 57)

Permeability - the capacity of a soil or rock for transmitting water under pressure. It is defined as the rate of discharge of water through a unit cross-sectional area of the rock at right angles to the direction of a flow if the hydraulic gradient is unity. (Ibid., p. 44)

Piezometric surface - an imaginary surface that everywhere coincides with the nonpumping level of the water in the aquifer. It is the surface to which the water from a given aquifer will rise under its full head. (Ibid., p. 38)

Porosity - the ratio of interstitial volume to total volume of material, usually expressed as a percentage.

Soil Moisture - moisture found in the ground above the water table.

Specific capacity - the rate of yield of a well per unit of drawdown. (Ibid., p. 62)

Storage coefficient - the volume of water released from, or taken into storage by an aquifer per unit surface area of the aquifer per unit change in the component of head normal to that surface. It is dimensionless.

Surficial deposits - those unconsolidated materials which overlie the consolidated bedrock, without respect to geologic age.

Till - unconsolidated glacial material characterized by its lack of stratification and heterogeneous assortment of clay, sand, pebble, and boulder size particles.

Transmissibility - the flow capacity of an aquifer in gallons per day per foot width, equal to the product of permeability times the saturated thickness of the aquifer. (Butler, 1959, p. 344)

Water table - the upper boundary of a free groundwater body, at atmospheric pressure. (Ibid.)

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APPENDIX

APPENDIX A: SUPPLEMENTARY CONDITIONS TO WELL LICENCE NO.

1. The well shall not produce water from a depth of less than fifty feet below the elevation of the base of the lowest aquifer which, when the well is drilled, water is being taken,

(a) within two miles of the well, and

(b) for farm or domestic use.

2. (1) The licencee shall, before the well is placed on production,

(a) if water for farm or domestic use is being taken within two miles of the well, case the well and cement the casing to the surface from a depth of fifty feet below the elevation of the base of the lowest aquifer from which water is being so taken, or

(b) if the water for farm or domestic use is not being taken within two miles of the well, case the well and cement the casing to the surface from the top of the highest water-producing sand or from a depth of twenty-five feet below the drift-bedrock (Paskapoo) contact, whichever is the shallower.

(2) The cementation of casing shall be done by the circulation method.

3. (1) The licensee shall complete the well in a manner that will permit the accurate measurement, at any time, of the water level in the well.

(2) The operator shall equip the well so that continuous measurement may be made of the water produced at the well or an approved group of wells.

4. (1) The licensee before placing the well on production, shall test pump

the well at the proposed production rate until its water level is stabilized for a period of twenty-four hours.

(2) The depth of the stabilized water level shall be measured and reported to the Board.

5. The Board may, at any time, restrict or prohibit the production of water from the well if, in its opinion, it is in the public interest to do so.

6. (1) The licensee shall supply to the Board within two weeks of the date at which the well is completed a driller's report containing (a) the well name, (b) the well location, (c) the elevation of the well, (d) the date drilled, (e) the total depth of the well, (f) the depth to drift-bedrock contact, (g) the casing size and landing point, (h) the amount of cement used to cement casing, (i) the size of the hole, (j) the depth to original water level, (k) the depth of pump setting, and (l) the results and details of pumping or bail tests.

(2) The licensee shall supply to the Board two copies of each log or water analysis taken within one month of when it is taken.

(3) The licensee shall, not later than the 15th day of the month following a month during which water was produced from the well, file in duplicate with the Board a report of the quantity of water produced during the preceding month.

(4) The licensee shall, at the end of each consecutive four-month period during which water was produced, file in duplicate a report of the depth to the stabilized water level.

APPENDIX B: TRUE TRANSMISSIBILITY COMPARED TO APPARENT TRANSMISSIBILITY

When a water well is drilled, the driller often conducts a brief bailing or pumping test. Only an initial water level and a final water level after a known period of water withdrawal are recorded. The final time and drawdown are plotted on semilogarithmic paper and joined by a straight line to the point of no drawdown and 0.1 minutes. (See Figure 15). By means of the formula

$$T \doteq \frac{264\ Q}{\Delta S} \tag{7}$$

in which T is transmissibility in gallons per day per foot width, Q the pumping rate in gallons per minute, and ΔS the drawdown in feet per log cycle, apparent transmissibility may be calculated.

True transmissibility is calculated from a best fit straight line curve passing through more than one measurement of time and drawdown. Measurements should be taken each minute for the first ten minutes, every five minutes for the next 40 minutes, and so on with a greater time interval between measurements as the test advances. The test should last as long as it is practically possible, but after about 24 hours, long periods of time normally become necessary for very small changes in drawdown. The resultant straight line curve, when used with equation (7), will yield true transmissibility.

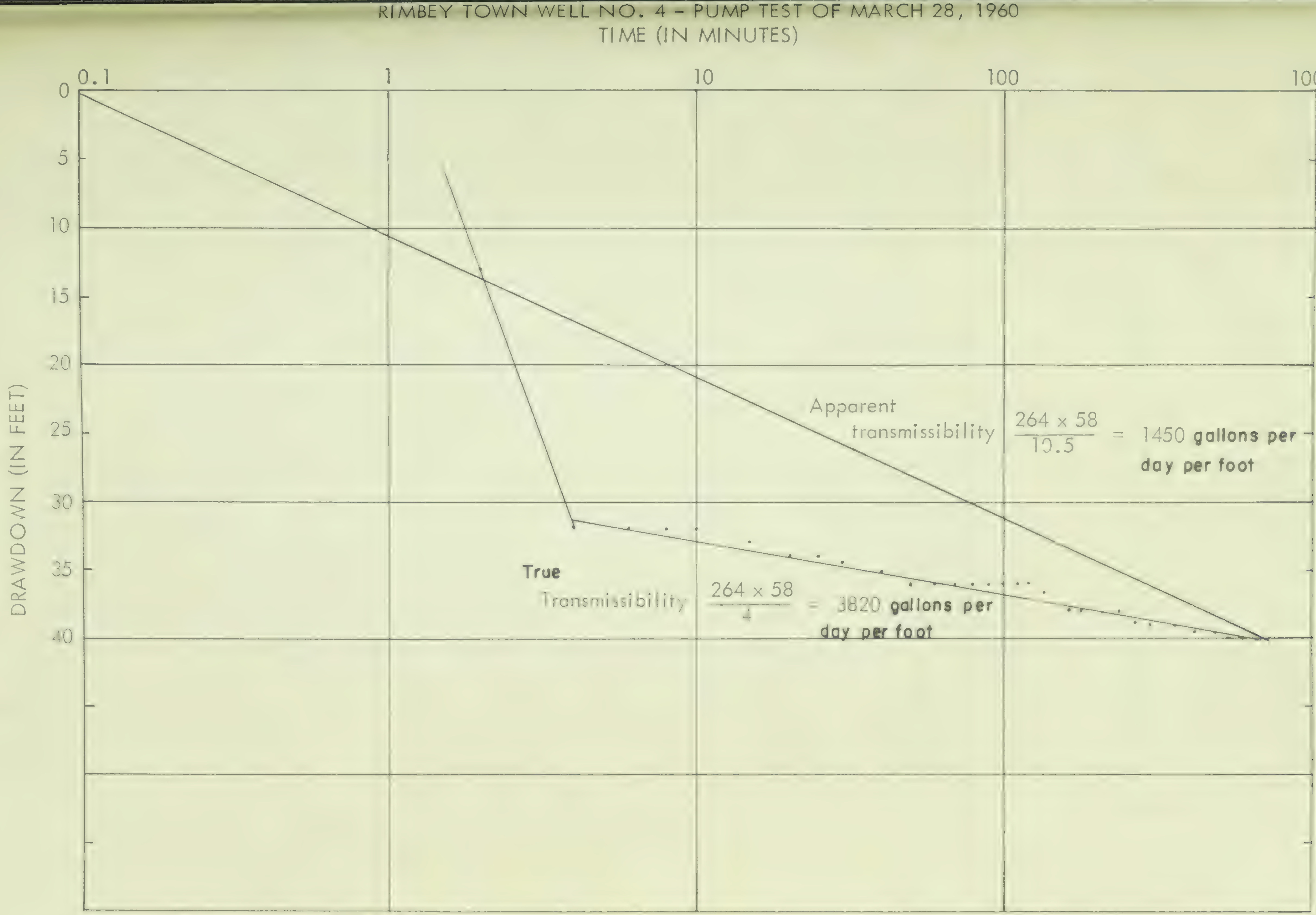

FIGURE 15. **TRUE** TRANSMISSIBILITY COMPARED WITH APPARENT TRANSMISSIBILITY

APPENDIX C: ELECTRIC LOG OF THE PASKAPOO FORMATION

The electric log in Figure 16 illustrates the typical lithology of the Paskapoo Formation. Although the lower part is largely sandy and the upper largely shaly, there are very rapid changes throughout the entire formation.

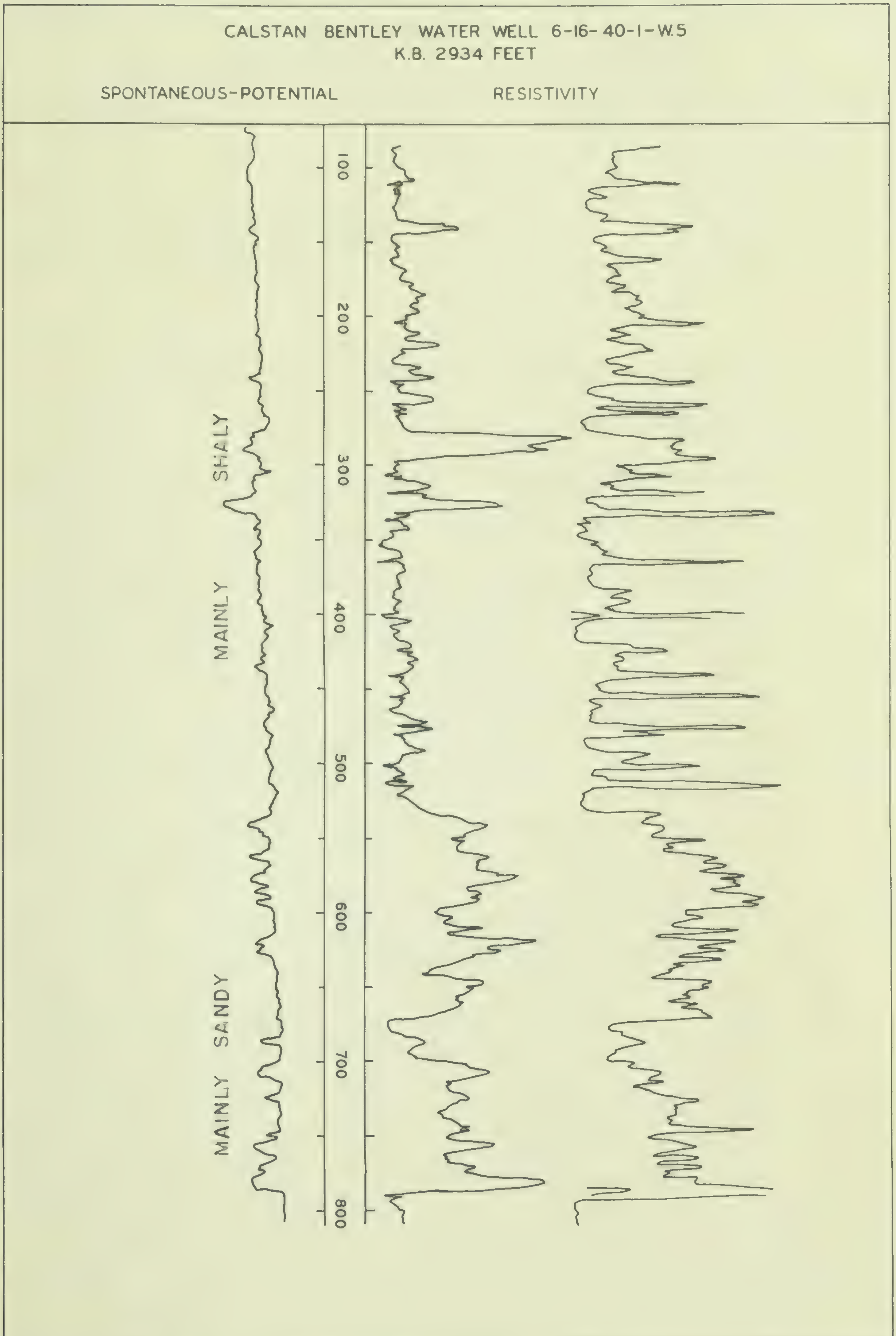

FIGURE 16. TYPICAL ELECTRIC LOG OF THE PASKAPOO FORMATION

APPENDIX D: SUMMARY OF WELLS

In this summary, all elevations and depths are in feet and yields in gallons per minute. In water type, S. is soft water, MH is medium hard water, and H is hard water. P means Paskapoo Formation and S surficial deposits. Most elevations were obtained by locating the wells on topographic maps of the scale 1:50,000, and estimating their elevation. Since some of these maps have a contour interval of 25 feet, and some of 50 feet, the well elevation should be accurate within about 10 feet. The elevations of wells measured by the Geological Survey of Canada were probably measured with an altimeter. However, since the writer is uncertain of this, the accuracy of these elevations is doubtful.

Location	Elev.	Depth of well	Depth to wa.	Depth to aquifer	Water Type	Yield	P.or S
SE-30-38-27-W.4	2845	305	60	19	-	13	P
NW-27-38-28-W.4	3120	96	48	16, 48	S	2	P
SE-26-38-28-W.4	3005	144	69	130	MH	20	P
NE-28-38-28-W.4	3120	90	18	-	-	-	P
NW-32-38-28-W.4	3180	-	90	-	S	-	P
SW-32-38-28-W.4.	3140	60	30	-	S	-	P
NW-33-38-28-W.4	3120	110	55	55	H	$\frac{1}{2}$	P
NW-33-38-28-W.4	3120	80	30	55	H	1	P

Location	Elev.	Depth of well	Depth to wa.	Depth tp aquifer	Water Type	Yield	P.or S
NW-34-38-28-W.4	3105	110	-	-	S	20	P
NE-35-38-28-W.4	2975	230	92	120, 221	S	12	P
NW-36-38-28-W.4	2975	130	-	-	MH	8	P
SW-4-39-27-W.4	2900	253	223	-	-	½	P
16-4-39-27-W.4	2885	170	65	130	MH	5	P
SE-4-39-27-W.4	2903	160	60	160	MH	-	P
SE-5-39-27-W.4	2900	206	18	-	-	-	P
SE-5-39-27-W.4	2918	124	74	124	H	-	P
SW-7-39-27-W.4	2941	26	-	26	MH	-	P
NW-10-39-27-W.4	2880	200	-	160	MH	2	P
NW-10-39-27-W.4	2894	194	120	194	MH	-	P
SW-10-39-27-W.4	2914	34	30	30	MH	-	S
SW-13-39-27-W.4	2850	50	35	35	H	-	S
SE-14-39-27-W.4	2871	175	-	175	S	-	P
NW-14-39-27-W.4	2820	65	18	60	MH	-	P
SW-15-39-27-W.4	2925	100	25	80	S	15	P
SW-15-39-27-W.4	2925	160	70	-	S	-	P
NW-15-39-27-W.4	2785	62	7	12, 59	S	-	P
NE-16-39-27-W.4	2790	64	9	60	S	2½	P
NE-16-39-27-W.4	2810	55	16	50	MH	-	P
SE-19-39-27-W.4	2935	40	23	-	H	-	P
NW-20-39-27-W.4	2947	52	20	52	S	-	P
NE-20-39-27-W.4	2900	110	30	100	H	-	P
NE-20-39-27-W.4	2900	60	30	60	H	-	P

Location	Elev.	Depth of well	Depth to wa.	Depth to Aquifer	Water type	Yield	P. or S
NW-21-39-27-W.4	2890	40	35	35	H	-	S
NE-21-39-27-W.4	2897	52	20	50	M	-	S
NE-21-39-27-W.4	2885	365	100	265	S	-	P
NW-22-39-27-W.4	2865	78	39	-	MH	-	P
NE-22-39-27-W.4	2875	55	20	20	H	-	S
NE-22-39-27-W.4	2875	214	140	190	S	10	P
NE-22-39-27-W.4	2875	16	12	16	MH	-	S
NE-23-39-27-W.4	2815	126	62	-	S	-	P
SE-23-39-27-W.4	2795	73	40	-	MH	14	P
SE-23-39-27-W.4	2816	10	7	7	H	-	S
5-23-39-27-W.4	2850	70	29	29	H	10	S
SW-24-39-27-W.4	2850	100	55	100	MH	15	P
SE-24-39-27-W.4	2830	160	25?	-	S	2	P
Blackfalds Town Hall	2880	230	117	-	S	12	P
Blackfalds CPR station	2885	40	35	35	H	-	S
Blackfalds Fire Hall	2880	180	113	-	S	30	P
Blackfalds School	2885	221	118	-	S	2	P
SW-27-39-27-W.4	2870	180	44	-	MH	-	P
SW-28-39-27-W.4	2910	90	-	90	H	-	P
SW-29-39-27-W.4	3060	80	20	-	MH	-	P
SE-1-39-28-W.4	3050	296	80	110	S	2	P
SE-2-39-28-W.4	3075	30	18	30	H	-	P
SE-2-39-28-W.4	3102	75	25	35, 70	H	3	P

Location	Elev.	Depth of Well	Depth to Wa.	Depth to Aquifer	Water Type	Yield	P.or S.
NW-2-39-28-W.4	3085	93	30	60	MH	-	P
NE-2-39-28-W.4	3070	68	28	28	H	12	P
NW-3-39-28-W.4	3100	70	14	30, 60	S	-	P
SE-3-39-28-W.4	3110	22	18	22	H	-	P
SE-3-39-28-W.4	3086	16	12	16	MH	-	P
SW-4-39-28-W.4	3111	20	12	12	H	-	S
SW-5-39-28-W.4	3155	170	68	165	S	3	P
NW-5-39-28-W.4	3150	73	50	68	S	-	P
NE-8-39-28-W.4	3084	30	15	15	H	-	S
SE-9-39-28-W.4	3065	70	20	68	S	-	P
NW-10-39-28-W.4	3030	90	30	-	MH	-	P
NW-10-39-28-W.5	3030	15	10	10	-	-	S
NE-10-39-28-W.4	3052	120	40	120	S	-	P
NE-10-39-28-W.4	3052	92	11	-	MH	2	P
SE-11-39-28-W.4	3033	16	6	6	MH	-	S
SW-12-39-28-W.4	3025	120	65	-	-	10	P
NE-15-39-28-W.4	3010	295	210	265	S	12	P
SW-16-39-28-W.4	3014	90	-	90	H	-	P
NW-17-39-28-W.4	2984	85	30	85	H	-	P
NW-17-39-28-W.4	2980	200	60	30	MH	-	P
SW-20-39-28-W.4	2975	150	-	150	MH	-	P
NE-21-39-28-W.4	2945	176	80	172	S	-	P
NE-22-39-28-W.4	3075	196	80	196	H	-	P
SW-22-39-28-W.4	3010	270	150	-	MH	-	P
13-23-39-28-W.4	3070	254	80	125, 220	MH	20	P

Location	Elev.	Depth of well	Depth to Wa.	Depth to Aquifer	Water Type	Yield	P. or S.
NE-23-39-28-W.4	3080	42	20	35	MH	6	P
NW-24-39-28-W.4	3085	33	27	33	H	4	P
SE-24-39-28-W.4	3060	186	98	54	-	6	P
SW-26-39-28-W.4	3055	117	50	117	H	-	P
NW-26-39-28-W.4	3057	180	30	180	S	-	P
NE-28-39-28-W.4	3011	83	45	83	S	-	P
SE-29-39-28-W.4	2843	30	25	-	MH	½	P
NE-33-39-28-W.4	2980	60	40	40	MH	-	P
NE-33-39-28-W.4	2980	81	27	80	-	-	P
NE-34-39-28-W.4	3035	116	40	116	MH	-	P
SE-34-39-28-W.4	3051	265	-	265	S	-	P
SW-35-39-28-W.4	3059	188	45	188	S	-	P
SW-35-39-28-W.4	3030	210	60	-	S	-	P
SW-36-39-28-W.4	3074	55	12	50	H	-	S
15-1-39-1-W.5	3145	80	30	-	MH	-	P
8-12-39-1-W.5	3100	22	12	-	MH	-	P
8-12-39-1-W.5	3094	25	12	-	MH	-	P
8-12-39-1-W.5	3108	120	40	40,80 120	S	-	P
4-12-39-1-W.5	3196	210	160	-	S	-	P
NE-12-39-1-W.5	3075	80	13	50	MH	20	P
7-13-39-1-W.5	3003	18	11	11	MH	-	P?
7-13-39-1-W.5	3000	35	20	-	H	-	P
9-14-39-1-W.5	2964	25	20	23	H	-	S
SE-14-39-1-W.5	3125	100	47	90	-	4	P
13-15-39-1-W.5	3221	134	60	80, 130	H	-	P

Location	Elev.	Depth of well	Depth to wa.	Depth to Aquifer	Water type	Yield	P.or S.
1-16-39-1-W.5	3219	190	100	-	MH	-	P
9-16-39-1-W.5	3251	92	70	-	-	-	P
14-20-39-1-W.5	3259	227	189	222	S	-	P
8-21-39-1-W.5	31[illegible]1	87	60	87	S	-	P
8-21-39-1-W.5	31[illegible]1	135	60	-	S	-	P
13-21-39-1-W.5	3211	90	65	-	MH	-	P
4-22-39-1-W.5	3165	187	120	60, 175	S	-	P
14-22-39-1-W.5	30[illegible]3	135	35	50, 130	S	-	P,S
SE-23-39-1-W.5	-	150	75	100	-	3	P
8-24-39-1-W.5	2981	300	60	52, 295	MH	-	P
5-24-39-1-W.5	2958	73	25	70	S	-	P
5-24-39-1-W.5	2951	80	25	70	S	-	P
13-24-39-1-W.5	2900	83	12	80	H	-	P
8-25-39-1-W.5	2831	3	1	3	S	-	S
4-26-39-1-W.5	2948	108	40	85	S	-	P
1-27-39-1-W.5	2988	80	30	72	MH	-	P
2-28-39-1-W.5	3186	80	58	-	MH	-	P
1-29-39-1-W.5	3200	80	70	-	MH	-	P
9-30-39-1-W.5	3230	240	160	240	S	-	P
9-30-39-1-W.5	3232	173	150	160	S	-	P
13-31-39-1-W.5	3081	196	119	195	S	-	P
13-31-39-1-W.5	3083	189	117	185	S	-	P
5-32-39-1-W.5	3040	253	100	-	S	-	P
16-32-39-1-W.5	2964	52	20	45	S	-	P

Location	Elev.	Depth of well	Depth to wa.	Depth to Aquifer	Water type	Yield	P.or S.
8-34-39-1-W.5	2969	45	12	40	S	-	P
5-34-39-1-1-W.5	2955	110	30	-	H	-	P
13-34-39-1-W.5	2909	90	60	-	MH	-	P
16-34-39-1-W.5	2973	235	75	-	S	-	P
9-36-39-1-W.5	2965	135	-	135	MH	-	P
8-35-39-2-W.5	3240	190	130	150, 190	S	-	P
5-36-39-2-W.5	3248	196	130	150, 190	MH	-	P
16-36-39-2-W.5	3173	150	100	150	S	-	P
NW-29-40-27-W.4	3080	200	150	200	H	2	P
SE-30-40-27-W.4	3065	160	-	-	H	5	P
SW-30-40-27-W.4	3048	18	-	18	H	-	S
SW-30-40-27-W.4	3048	315	112	315	H	-	P
NW-30-40-27-W.4	3063	165	-	165	H	-	P
SE-2-40-28-W.4	3075	80	-	30, 80	S	-	P
NE-2-40-28-W.4	3075	90	30	20, 85	S	-	P
NE-2-40-28-W.4	3083	60	10	60	MH	-	P
NW-2-40-28-W.4	3059	85	35	85	MH	-	P
SW-2-40-28-W.4	3056	83	35	83	MH	-	P
SW-3-40-28-W.4	3032	94	30	94	S	-	P
SW-9-40-28-W.4	3040	73	16	70	S	-	P
SW-9-40-28-W.4	3040	132	15	60, 96	S	-	P
NW-11-40-28-W.4	3056	92	55	92	MH	-	P

Location	Elev.	Depth of well	Depth to wa.	Depth to Aquifer	Water type	Yield	P.or S.
NW-12-40-28-W.4	3091	93	20	93	MH	-	P
SW-13-40-28-W.4	3082	90	30	90	S	-	P
SE-13-40-28-W.4	3070	110	90	100	S	-	P
NE-15-40-28-W.4	2985	125	75	125	S	-	P
SE-16-40-28-W.4	3055	108	100	-	H	-	P
NW-16-40-28-W.4	3049	69	29	69	MH	-	P
SW-24-40-28-W.4	3029	105	50	105	MH	-	P
SE-24-40-28-W.4	3063	186	-	186	H	-	P
SE-26-40-28-W.4	3003	103	25	103	MH	-	P
NE-36-40-28-W.4	3023	165	72	165	-	-	P
SW-36-40-28-W.4	2980	210	75	210	MH	-	P
11-2-40-1-W.5	2923	35	20	-	S	-	P
2-4-40-1-W.5	2932	80	40	-	S	-	P
SW-4-40-1-W.5	2925	110	66	-	S	7	P
1-5-40-1-W.5	2966	80	17	77	S	-	P
3-6-40-1-W.5	3023	10	6	6	H	-	S
8-7-40-1-W.5	2936	60	15	30, 60	S	-	P
8-7-40-1-W.5	2934	90	15	60	S	-	P
5-8-40-1-W.5	2943	77	30	30,60 75	S	-	P
16-9-40-1-W.5	2892	120	60	-	S	-	P
8-10-40-1-W.5	2917	90	50	-	MH	-	P
5-10-40-1-W.5	2852	135	flows	135	S	-	P
4-12-40-1-W.5	2961	84	34	-	S	-	P
13-12-40-1-W.5	2986	78	25	75	S	-	P

Location	Elev.	Depth of well	Depth to wa.	Depth to Aquifer	Water type	Yield	P.or S.
NE-13-40-1-W.5	3039	148	75	45, 145	S	-	P
13-13-40-1-W.5	3029	120	65	-	S	-	P
9-13-40-1-W.5	3037	148	68	120, 145	S	-	P
7-14-40-1-W.5	2978	100	17	90	MH	-	P
3-15-40-1-W.5	2887	88	30	34, 88	S	-	P
4-16-40-1-W.5	2934	93	-	40, 90	S	-	P
6-16-40-1-W.5	2926	804	-	-	S	34	P
13-17-40-1-W.5	2983	112	60	65, 110	MH	-	P
14-19-40-1-W.5	3169	130	95	-	MH	-	P
16-19-40-1-W.5	3169	204	165	-	H	-	P
1-20-40-1-W.5	2966	55	14	55	MH	-	P
1-20-40-1-W.5	2967	56	15	56	MH	-	P
3-21-40-1-W.5	2944	160	-	80, 160	S	-	P
1-22-40-1-W.5	2949	65	12	-	S	-	P
14-22-40-1-W.5	2913	35	25	-	S	-	P
16-22-40-1-W.5 (Creamery)	-	181	41	85, 168	S	24	P
Bentley, CPR.	2970	113	28	100	S	-	P
8-23-40-1-W.5	3054	-	124	-	S	-	P
13-23-40-1-W.5	3000	89	61	85	S	10	P
14-23-40-1-W.5	3025	124	95	120	-	8	P
Bentley, Community Hall	2990	100	35	95	S	8	P

Location	Elev.	Depth of well	Depth to wa.	Depth to Aquifer	Water type	Yield	P.or S.
5-24-40-1-W.5	3075	200	140	-	S	-	P
13-24-40-1-W.5	3098	193	180	-	S	-	P
NW-24-40-1-W.5	3070	1[illegible]0	90	-	S	-	P
1-25-40-1-W.5	3031	100	65	75	S	-	P
2-26-40-1-W.5	3068	135	125	135	S	-	P
Bentley,School	2990	100	88	95	S	20	P
4-26-40-1-W.5	3000	102	60	95	S	8	P
SW-26-40-1-W.5	3000	82	50	75	S	10	P
Bentley Coin Wash	2995	170	45	85, 119	MH	23	P
3-27-40-1-W.5	2910	35	18	18	S	-	P
11-27-40-1-W.5	2914	70	40	38, 70	S	-	P
4-28-40-1-W.5	2940	84	13	30, 82	MH	-	P
2-29-40-1-W.5	2991	132	35	-	S	-	P
12-29-40-1-W.5	3035	104	50	100	-	-	P
NW-29-40-1-W.5	--	83	40	70	-	10	P
9-29-40-1-W.5	2946	68	18	62	MH	-	P
10-34-40-1-W.5	3028	196	110	-	S	-	P
NE-34-40-1-W.5	3010	250	35	190	S	-	P
7-35-40-1-W.5	2974	140	60	-	S	-	P
SW-35-40-1-W.5	3020	165	55	-	S	-	P
SE-35-40-1-W.5	3000	98	20	-	S	-	P
NW-35-40-1-W.5	3040	115	80	76, 115	S	-	P
SW-36-40-1-W.5	3010	96	[illegible]	90	S	10	P

Location	Elev.	Depth of well	Depth to wa.	Depth to Aquifer	Water type	Yield	P. or S.
7-1-40-2-W.5	3051	99	33	65, 99	MH	-	P
1-2-40-2-W.5	3210	205	105	105	S	-	P
1-3-40-2-W.5	3272	230	160	200, 230	MH	-	P
9-3-40-2-W.5	3198	200	32	85, 140	MH	-	P
5-9-40-2-W.5	3199	203	82	-	S	-	P
9-11-40-2-W.5	2970	90	8	27,62, 90	MH	-	P
2-12-40-2-W.5	3024	130	100	40	S	-	P
14-12-40-2-W.5	2968	115	60	-	S	-	P
15-12-40-2-W.5	2955	167	23	40, 160	S	-	P
7-14-40-2-W.5	3024	102	15	-	S	-	P
6-14-40-2-W.5	3004	133	16	40, 130	MH	-	P
SW-14-40-2-W.5	2984	85	7	-	MH	-	P
9-14-40-2-W.5	2963	125	10	-	S	-	P
SW-15-40-2-W.5	3044	65	9	44, 60	MH	-	P
SE-15-40-2-W.5	2997	70	8	69	S	-	P
11-15-40-2-W.5	3057	160	60	156	MH	-	P
14-16-40-2-W.5	3052	54	2	54	-	-	P
11-21-40-2-W.5	3264	240	170	240	MH	-	P
4-22-40-2-W.5	3162	107	90	-	MH	-	P
9-23-40-2-W.5	3015	62	Flows, +1	-	S	-	P
9-23-40-2-W.5	3015	90	Flows, +3	80	-	-	P
NW-23-40-2-W.5	3005	90	10	27, 85	S	-	P

Location	Elev.	Depth to well	Depth to wa.	Depth to Aquifer	Water type	Yield	P.or S.
2-24-40-2-W.5	2960	37	7	27	S	-	P
SE-24-40-2-W.5	2990	125	29	-	-	-	P
SE-24-40-2-W.5	2973	41	[illegible]	30	S	-	P
5-24-40-2-W.5	2984	74	12	52, 72	S	-	P
12-24-40-2-W.5	3045	60	30	-	MH	-	P
12-25-40-2-W.5	3151	160	-	60	S	-	P
8-28-40-2-W.5	3031	195	6	-	H	-	P
16-30-40-2-W.5	3172	105	67	100	S	-	P
8-31-40-2-W.5	3146	13[illegible]	90	80, 125	S	-	P
13-31-40-2-W.5	3190	110	30	-	S	-	P
16-31-40-2-W.5	3162	65	20	-	H	-	P
13-32-40-2-W.5	3161	105	35	60, 100	S	-	P
10-33-40-2-W.5	3113	136	18	127, 135	MH	-	P
3-34-40-2-W.5	3178	1[illegible]5	Flows	-	MH	-	P
11-34-40-2-W.5	3116	90	10	27, 85	MH	-	P
3-25-40-3-W.5	3275	52	25	-	MH	-	P
3-26-40-3-W.5	3207	140	70	-	H	-	P
14-36-40-3-W.5	3343	141	120	130	H	-	P
NW-5-41-27-W.4	3050	18	16	18	H	-	P
SE-6-41-27-W.4	3050	40	-	40	H	-	P
NW-6-41-27-W.4	3020	164	24	164	H	-	?
SW-8-41-27-W.4	[illegible]060	28	20	28	H	-	S

Location	Elev.	Depth to well	Depth to wa.	Depth to aquifer	Water type	Yield	P. or S.
W½-8-41-27-W.4	3040	21	18	-	H	-	S
SW-1-41-28-W.4	2985	150	24	-	S	-	P
SW-1-41-28-W.4	2980	132	15	132	H	-	P
SE-1-41-28-W.4	3005	142	40	-	H	-	P
SE-1-41-28-W.4	3005	165	-	165	-	-	P
SE-2-41-28-W.4	3000	144	65	90, 144	S	-	P
NW-2-41-28-W.4	2970	116	30	115	S	-	P
NE-10-41-28-W.4	2975	90	20	85	S	-	P
SW-12-41-28-W.4	2960	74	6	74	S	-	P
SE-12-41-28-W.4	2960	30	-	30	H	-	P
NE-13-41-28-W.4	3050	107	20	-	SH	-	P
NW-14-41-28-W.4	2990	85	32	85	S	-	P
10-[illegible]-41-28-W.4	2980	90	12	35	-	10	P
SW-23-41-28-W.4	3010	96	14	96	S	-	P
SE-23-41-28-W.4	3040	85	14	85	S	-	P
SW-24-41-28-W.4	3030	60	25	58	H	-	P
NW-24-41-28-W.4	3040	90	24	46, 70	SH	-	P
NE-33-41-28-W.4	3025	70	29	35, 60	SH	5½	P
4-3-41-1-W.5	3000	115	60	20, 105	H	-	P
4-3-41-1-W.5	2994	169	89	-	H	-	P
9-4-41-1-W.5	3002	130	-	115	H	-	P
1-5-41-1-W.5	2875	57	15	25, 57	S	-	P
8-6-41-1-W.5	3018	60	30	30	S	-	P

Location	Elev.	Depth of well	Depth to wa.	Depth to Aquifer	Water Type	Yield	P.or S.
8-6-41-1-W.5	3021	40	30	-	S	-	P
10-7-41-1-W.5	2926	82	48	80	S	-	P
4-8-41-1-W.5	2922	80	40	-	S	-	P
8-9-41-1-W.5	3070	234	93	233	S	-	P
6-12-41-1-W.5	2992	57	20	-	S	-	P
12-12-41-1-W.5	2971	120	15	120	S	-	P
5-14-41-1-W.5	2982	120	30	-	MH	-	P
5-14-41-1-W.5	3001	102	20	-	H	-	P
8-16-41-1-W.5	3070	209	180	-	S	-	P
1-17-41-1-W.5	2876	61	40	60	MH	-	P
14-19-41-1-W.5	2896	99	17	53, 99	S	-	P
14-19-41-1-W.5	2890	52	25	52	H	-	P
4-20-41-1-W.5	3004	3	2	3	H	-	S
8-21-41-1-W.5	3080	295	225	-	S	-	P
14-21-41-1-W.5	3108	200	45	-	S	-	P
4-22-41-1-W.5	3076	140	90	-	S	-	P
5-29-41-1-W.5	3065	80	60	-	MH	-	P
12-30-41-1-W.5	2972	80	7	-	MH	-	P
16-30-41-1-W.5	3055	60	25	-	S	-	P
16-30-41-1-W.5	3050	95	45	90	S	-	P
1-30-41-1-W.5	3020	112	28	25, 107	MH	-	P
1-31-41-1-W.5	3029	30	10	-	H	-	S
8-32-41-1-W.5	3049	135	75	-	MH	-	P
14-32-41-1-W.5	3105	132	100	-	S	-	P
14-32-41-1-W.5	3099	155	100	-	S	-	P

Location	Elev.	Depth of well	Depth to wa.	Depth to aquifer	Water type	Yield	P. or S.
NW-1-41-2-W.5	3118	135	90	-	S	-	P
9-1-41-2-W.5	3090	132	70	90	H	-	P
2-2-41-2-W.5	3226	160	35	-	MH	-	P
4-3-41-2-W.5	3119	12	11	11	H	-	P
11-3-41-2-W.5	3150	135	20	35	S	-	P
8-4-41-2-W.5	3095	53	flows	53	H	-	P
13-5-41-2-W.5	3179	110	70	-	S	-	P
14-5-41-2-W.5	3148	115	40	100	S	-	P
7-6-41-2-W.5	3187	98	55	70	S	-	P
13-7-41-2-W.5	3152	24	14	-	H	-	[illegible]
1-9-41-2-W.5	3117	42	flows	-	MH	-	P
14-9-41-2-W.5	3153	63	32	-	H	-	P
15-9-41-2-W.5	3178	70	50	-	H	-	P
7-10-41-2-W.5	3198	8	7	[illegible]	H	-	S
4-10-41-2-W.5	3135	26	8	26	MH	-	P
14-12-41-2-W.5	3010	20	flows	20	MH	-	P
NE-13-41-2-W.5	2960	93	64	-	MH	-	P
2-13-41-2-W.5	2983	80	50	-	MH	-	P
3-13-41-2-W.5	2995	95	17	17,47, 95	[illegible]	-	P
3-13-41-2-W.5	2991	47	6	17,47	H	-	P
9-15-41-2-W.5	3150	111	80	110	MH	-	P
SW-16-41-2-W.5	3192	90	65	90	S	-	P
9-19-41-2-W.5	3177	135	95	130	MH	-	P
16-23-41-2-W.5	2986	120	40	120	S	-	P
11-24-41-2-W.5	2898	112	80	-	MH	-	P

Location	Elev.	Depth of well	Depth to wa.	Depth to aquifer	Water type	Yield	P.or S.
15-24-41-2-W.5	2902	22	8	-	H	-	P
15-24-41-2-W.5	2894	20	15	-	H	-	P
10-25-41-2-W.5	2904	96	25	96	S	-	P
10-25-41-2-W.5	2902	96	25	96	S	-	P
9-25-41-2-W.5	2916	40	14	20	MH	-	P
16-25-41-2-W.5	2980	12	11	-	H	-	S
16-27-41-2-W.5	3041	200	45	60	H	-	P
1-28-41-2-W.5	3000	110	92	110	S	2	P
13-28-41-2-W.5	3055	15	8	10	H	-	P
1-31-41-2-W.5	3060	63	10	9,60	MH	-	P
4-32-41-2-W.5	3085	55	15	-	S	-	P
13-32-41-2-W.5	3046	51	14	45	H	-	P
9-32-41-2-W.5	3146	90	75	-	H	-	P
9-32-41-2-W.5	3124	110	50	-	H	-	P
9-34-41-2-W.5	2985	60	40	-	MH	-	P
NE-34-41-2-W.5	3000	70	20	-	H	-	P
NE-34-41-2-W.5	3000	90	30	60	H	-	P
8-13-41-3-W.5	3149	93	14	40,93	S	-	P
9-13-41-3-W.5	3157	120	20	80	S	-	P
3-14-41-3-W.5	3231	107	90	80	S	-	P
12-14-41-3-W.5	3256	120	70	90	S	-	P
1-25-41-3-W.5	3153	135	27	135	S	-	P
9-25-41-3-W.5	3135	142	30	35	S	-	P
1-26-41-3-W.5	3160	20	16	19	H	-	S
4-34-41-3-W.5	3326	83	35	-	H	-	P

Location	Elev.	Depth of well	Depth to wa.	Depth to aquifer	Water type	Yield	P.or S.
NW-34-41-3-W.5	3250	102	30	90	MH	-	P
15-34-41-3-W.5	3232	100	60	60	MH	-	P
4-35-41-3-W.5	3162	50	30	-	MH	-	P
NE-35-41-3-W.5	3200?	65	-	30,60	S	-	P
7-36-41-3-W.5	3131	160	90	-	S	-	P
6-36-41-3-W.5	3085	15	5	15	MH	-	P
9-36-41-3-W.5	3045	41	11	34	H	10	P
SW-3-42-28-W.4	3145	150	125	145	S	-	P
SE-4-42-28-W.4	3100	175	-	175	S	-	P
SW-4-42-28-W.4	3000	18	-	18	H	-	P
SE-8-42-28-W.4	-	170	130	150	S	-	P
NW-9-42-28-W.4	3120	98	88	90	H	-	P
SE-9-42-28-W.4	3100	114	-	114	S	-	P
SW-17-42-28-W.4	3025	54	10	-	S	-	P
SW-3-42-1-W.5	2960	70	7	55	-	$1\frac{1}{2}$	P
SW-3-42-1-W.5	2960	60	13	53	-	10	P
NE-4-42-1-W.5	2990	80	20	-	H	-	P
SW-5-42-1-W.5	3070	155	-	70, 155	S	-	P
SE-6-42-1-W.5	3055	95	55	90	S	-	P
NE-6-42-1-W.5	3105	10	8	8	H	-	S
SE-7-42-1-W.5	3120	140	70	-	S	-	P
SE-9-42-1-W.5	2975	210	35	-	H	-	P
NE-14-42-1-W.5	2990	48	10	40	MH	-	P
NW-16-42-1-W.5	-	53	20	45	H	-	P

Location	Elev.	Depth of well	Depth to wa.	Depth to aquifer	Water type	Yield	P. or S.
16-16-42-1-W.5	3000	43	flows ≠ 7	18, 40	S	-	P
SW-17-42-1-W.5	3150	40	25	20	H	-	S?
4-18-42-1-W.5	3100	60	25	35,60	S	9	P
5-6-18-42-1-W.5	3120	60	25	52	MH	6	P
NE-19-42-1-W.5	3170	130	100	-	S	-	P
SW-22-42-1-W.5	2980	68	3	68	S	-	P
SW-24-42-1-W.5	3010	70	30	50	MH	-	P
7-26-42-1-W.5	2995	50	24	29,42	MH	7	P
NE-26-42-1-W.5	3000	46	26	-	MH	-	P
SE-26-42-1-W.5	2990	130	12	80	-	5	P
NW-27-42-1-W.5	2980	68	4	-	-	-	P
7-28-42-1-W.5	2975	65	flows	50	MH	10	P
SW-30-42-1-W.5	3135	56	50	-	H	-	P
NW-30-42-1-W.5	3140	175	125	175	H	-	P
10-30-42-1-W.5	3105	117	102	85,105	S	5	P
NW-31-42-1-W.5	3050	49	11	25,48	H	7	P
13-31-42-1-W.5	3050	61	34	45	MH	7	P
SW-34-42-1-W.5	2975	80	flows	60	S	-	P
NW-36-42-1-W.5	3080	127.5	90	114	H	5	P
3-1-42-2-W.5	2948	63	40	-	S	-	P
SW-1-42-2-W.5	2950	60	50	60	S	6	P
1-2-42-2-W.5	2902	35	9	35	S	-	P
1-2-42-2-W.5	2901	35	6	35	S	35	P
4-2-42-2-W.5	2880	56	22	40	MH	10	P

Location	Elev.	Depth of well	Depth to wa.	Depth to aquifer	Water type	Yield	P.or S.
SW-2-42-2-W.5	2885	55	20	55	-	-	P
SW-2-42-2-W.5	2885	90	20	55	S	-	P
NW-3-42-2-W.5	2900	57	15	-	S	-	P
2-4-42-2-W.5	3053	87	6	40	H	-	P
SW-5-42-2-W.5	3040	50	25	-	H	-	P
NE-6-42-2-W.5	3075	100	75	50, 100	S	-	P
SE-6-42-2-W.5	3075	80	20	-	S	-	P
1-7-42-2-W.5	3115	122	62	94	S	10	P
NW-8-42-2-W.5	3025	119	68	103	S	8	P
NE-8-42-2-W.5	2925	114	20	22, 100	S	-	P
NE-12-42-2-W.5	3048	130	80	130	S	-	P
SW-13-42-2-W.5	3000	90	30	87	S	-	P
4-13-42-2-W.5	2980	90	6	23, 80	S	3	P
16-13-42-2-W.5	3105	50	14	30	MH	7	P
SW-14-42-2-W.5	2950	20	10	20	S	-	P
NW-14-42-2-W.5	2945	50	10	-	-	-	P
SE-16-42-2-W.5	2925	90	12	-	MH	-	P
SE-16-42-2-W.5	2925	70	30	-	S	-	P
NW-16-42-2-W.5	2950	140	68	80, 135	H	-	P
SE-17-42-2-W.5	2925	83	-	50,80	S	-	P
8-17-42-2-W.5	2910	80	30	74	-	20	P
SW-17-42-2-W.5	2980	67	40	-	MH	-	P
NE-17-42-2-W.5	2960	70	60	65	MH	-	P

Location	Elev.	Depth of well	Depth to wa.	Depth to aquifer	Water type	Yield	P. or S.
NE-19-42-2-W.5	2950	87	65	-	H	-	P
NW-20-42-2-W.5	3010	170	85	-	S	-	P
Rimbey, Town Well #3	-	205	103	90,165, 175	S	19	P
Rimbey, Town Well #1	-	203	142	-	MH	58	P
Rimbey, Town Well #2	-	202	104	5[illegible],119, 168	S	25	P
Rimbey, Town Well #4	-	325	100	-	S	58	P
SW-22-42-2-W.5	2980	120	50	50,80	S	-	P
NW-22-42-2-W.5	2950	63	20	60	MH	-	P
NE-23-42-2-W.5	3050	80	80	-	H	-	P
NW-23-42-2-W.5	2965	80	50	50,75	H	-	P
4-29-42-2-W.5	2945	129	60	50,9[illegible], 110	S	10	P
SE-30-42-2-W.5	2920	87	15	-	S	-	P
SW-30-42-2-W.5	2965	85	-	30	S	-	P
SW-31-42-2-W.5	3020	78	30	-	MH	-	P
NW-32-42-2-W.5	3010	163	140	-	MH	-	P
SE-34-42-2-W.5	3020	80	20	-	S	-	P
NE-34-42-2-W.5	3000	60	20	45	H	-	P
NW-35-42-2-W.5	3075	152	55	-	MH	-	P
NW-35-42-2-W.5	3075	122	40	90,20	S	-	P
SW-1-42-3-W.5	3105	93	47	70	S	1[illegible]	P
SE-3-42-3-W.5	3220	125	42	-	MH	-	P
NE-4-42-3-W.5	3320	180	147	113, 172	S	-	P

Location	Elev.	Depth of well	Depth to wa.	Depth to aquifer	Water type	Yield	P.or S.
NW-4-42-3-W.5	3275	70	30	-	H	-	P
SW-4-42-3-W.5	3300	80	40	-	MH	-	P
NE-9-42-3-W.5	3250	70	65	-	S	-	P
SW-10-42-3-W.5	3250	170	60	135, 165	S	10	P
3-15-42-3-W.5	3175	40	7	18,24	H	6	P,S
NE-17-42-3-W.5	3300	90	70	70	MH	-	P
1-18-42-3-W.5	3245	72	40	60,66	MH	7	P
SW-18-42-3-W.5	3175	65	7	-	H	-	P
NW-18-42-3-W.5	3240	76	56	-	S	-	P
SE-21-42-3-W.5	3200	96	35	50,90	S	7	P
NE-22-42-3-W.5	3140	82	42	40,80	H	-	P
NW-23-42-3-W.5	3145	92	50	-	H	-	P
SE-23-42-3-W.5	3085	120	15	50,115	S	-	P
SE-24-42-3-W.5	3045	130	15	50,120	S	-	P
NW-24-42-3-W.5	3055	73	30	65	H	-	P
SW-26-42-3-W.5	3110	195	60	150,170, 195	S	-	P
SE-27-42-3-W.5	3145	87	22	67,85	S	-	P
NW-28-42-3-W.5	3120	50	20	-	H	-	P
SE-28-42-3-W.5	3185	70	45	-	S	-	P
SW-30-42-3-W.5	3295	70	-	65	-	-	P
SE-31-42-3-W.5	3245	57	39	-	MH	-	P
SE-33-42-3-W.5	3090	75	6	-	S	-	P
NE-33-42-3-W.5	3190	110	80	105	H	-	P
NW-33-42-3-W.5	3150	111	73	105	H	-	P

Location	Elev.	Depth of well	Depth to wa.	Depth to aquifer	Water type	Yield	P. or S.
SW-34-42-3-W.5	3105	48	28	-	-	-	P
NE-35-42-3-W.5	3045	82	15	50,80	S	-	P
NW-35-42-3-W.5	3075	90	7	65	S	-	P
SW-3-43-1-W.5	3034	82	11	-	-	4	P
9-7-43-1-W.5	-	65	20	55,64	H	4	P,S
SW-19-43-1-W.5	2980	18	3	83	S	-	P
SW-28-43-1-W.5	3080	222	180	120	S	-	P
SW-2-43-2-W.5	3105	132	90	132	S	-	P
NE-2-43-2-W.5	3125	170	-	-	-	3	P
NW-2-43-2-W.5	3175	65	25	40	-	-	P
SE-3-43-2-W.5	3075	85	80	-	H	-	P
SW-3-43-2-W.5	3005	60	28	-	H	-	P
NW-4-43-2-W.5	2970	40	9	-	H	-	P
15-4-43-2-W.5	2980	45	flows/1	14, 43	H	10	P
SW-5-43-2-W.5	3110	110	95	-	MH	-	P
SW-7-43-2-W.5	3100	200	30	90,198	S	-	P
NW-8-43-2-W.5	2950	90	40	-	S	-	P
NW-9-43-2-W.5	2955	65	10	-	S	-	P
13-9-43-2-W.5	2940	41	11	20	H	8	P
NE-9-43-2-W.5	2980	40	8	22	H	-	P
SW-11-43-2-W.5	3080	160	120	-	H	-	P
NW-12-43-2-W.5	3000	45	20	45	H	-	P
NW-12-43-2-W.5	3000	95	40	45,95	MH	-	P
SW-12-43-2-W.5	3040	90	50	-	MH	-	P
SE-13-43-2-W.5	2990	90	22	42,75 95	-	-	P

Location	Elev.	Depth of well	Depth to wa.	Depth to aquifer	Water type	Yield	P.or S.
SE-13-43-2-W.5	2990	42	20	-	-	-	P
SE-13-43-2-W.5	2990	95	33	42,90	S	5	P
SE-14-43-2-W.5	3053	85	70	-	-	-	P
E½-15-43-2-W.5	3100	150	-	90,150	S	-	P
8-15-43-2-W.5	3070	150	105	149	H	6	P
SW-17-43-2-W.5	3000	85	flows	80	H	-	P
SW-19-43-2-W.5	3170	151	45	-	S	-	P
SW-19-43-2-W.5	3170	153	45	-	S	-	P
NW-19-43-2-W.5	3050	64	23½	-	-	-	P
NW-21-43-2-W.5	2940	42	12	8	H	-	P
SE-21-43-2-W.5	3050	217	150	-	MH	-	P
NW-22-43-2-W.5	3080	125	76	-	S	-	P
NE-22-43-2-W.5	3065	100	20	80	H	-	P
SW-23-43-2-W.5	3070	110	30	60,100	S	-	P
SW-23-43-2-W.5	3065	60	30	60	H	-	P
NW-23-43-2-W.5	3085	158	30	86,101 155	S	-	P
SE-24-43-2-W.5	2995	60	12	-	-	-	P
NW-24-43-2-W.5	2980	60	10	-	S	-	P
SW-25-43-2-W.5	2945	49	18	-	MH	-	P
SW-27-43-2-W.5	3050	70	40	65	S	-	P
SE-28-43-2-W.5	3025	103	90	-	S	-	P
NE-29-43-2-W.5	-	20	12	20	MH	-	S
SE-30-43-2-W.5	2970	120	flows	119	-	-	P
SW-30-43-2-W.5	3020	48	12	-	MH	-	P
NE-30-43-2-W.5	2945	20	12	20	MH	-	S

Location	Elev.	Depth of well	Depth to wa.	Depth to aquifer	Water type	Yield	P. or S.
Bluffton, Post Office	3000	69	30	40,55	H	10	P
NE-31-43-2-W.5	3005	73	30	-	H	-	P
NE-32-43-2-W.5	3110	100	35	56	H	-	P
SE-33-43-2-W.5	3055	220	160	-	-	-	P
SW-34-43-2-W.5	3045	70	12	40,65	H	-	P
NW-34-43-2-W.5	3040	70	23	50	S	-	P
NW-36-43-2-W.5	3125	45	15	43	S	-	P
NW-1-43-3-W.5	3085	80	60	70	H	-	P
NE-2-43-3-W.5	3048	55	13	-	S	-	P
SW-3-43-3-W.5	3170	100	80	-	H	-	P
SW-4-43-3-W.5	3145	97	60	60,85	S	-	P
NE-7-43-3-W.5	3340	115	25	-	-	-	P
NW-10-43-3-W.5	3100	55	25	25,45	MH	-	P
5-10-43-3-W.5	3060	50	8	18,40	MH	7	P
NE-11-43-3-W.5	3090	80	35	-	S	-	P
SE-12-43-3-W.5	3095	56	30	-	H	-	P
NE-13-43-3-W.5	3180	45	18	40	MH	-	P
9-13-43-3-W.5	3185	90	41	55,80	S	5	P
SW-15-43-3-W.5	3102	50	18	30,45	S	-	P
NE-15-43-3-W.5	3125	20	8	-	S	-	P
SW-16-43-3-W.5	3145	56	36	-	S	-	P
SE-17-43-3-W.5	3203	121	94	94	S	-	P
SE-18-43-3-W.5	3350	115	100	-	H	-	P
SW-18-43-3-W.5	3285	35	10	-	H	-	P
NW-19-43-3-W.5	3248	65	40	-	H	-	P

Location	Elev.	Depth of well	Depth to wa.	Depth to aquifer	Water type	Yield	P. or S.
NW-20-43-3-W.5	3205	105	45	-	MH	-	P
SE-20-43-3-W.5	3145	60	17	-	MH	-	P
SW-21-43-3-W.5	3175	62	20	40,55	H	-	P
SW-21-43-3-W.5	3175	32	10	-	-	-	P
SE-21-43-3-W.5	3180	90	35	60	H	-	P
NW-22-43-3-W.5	3290	125	40	40	MH	-	P
NW-27-43-3-W.5	3130	110	16	-	S	-	P
NW-27-43-3-W.5	3130	25	12	-	H	-	S?
NW-28-43-3-W.5	3195	100	40	80,98	H	-	P
NE-28-43-3-W.5	3155	65	40	-	MH	-	P
NE-30-43-3-W.5	3150	140	60	-	MH	-	P
NW-34-43-3-W.5	3155	82	40	80	S	-	P
NE-35-43-3-W.5	3050	57	25	-	H	-	P
NW-35-43-3-W.5	3060	74	15	68	H	-	P
NW-35-43-3-W.5	3060	35	12	-	H	-	P
SW-36-43-3-W.5	3048	60	12	-	S	-	P
NE-12-43-4-W.5	3265	65	45	-	MH	$\frac{1}{2}$	P
SE-14-43-4-W.5	3365	144	40	-	-	-	P
NW-27-43-4-W.5	3345	60	35	-	H	-	P
2-5-44-1-W.5	-	194	132	160	S	45	P
2-5-44-1-W.5	-	307	137	140, 169, 194	S	35	P
5-5-44-1-W.5	-	200	17	-	S	98	P
W$\frac{1}{2}$-6-44-1-W.5	3050	200	65	-	S	-	P

Location	Elev.	Depth of well	Depth to wa.	Depth to aquifer	Water type	Yield	P. or S.
SW-7-44-1-W.5	2980	120	18	90	MH	10	P
4-3-44-2-W.5	3105	75	48	65	MH	6	P
SW-4-44-2-W.5	3085	50	30	-	MH	-	P
SW-5-44-2-W.5	3055	135	44	-	MH	-	P
SW-6-44-2-W.5	2980	64	11	-	MH	-	P
4-6-44-2-W.5	2980	142	40	140	S	6	P
SW-6-44-2-W.5	2980	77	50	59	MH	10	P
NE-7-44-2-W.5	2145	16	15	15	H	-	S
NE-12-44-2-W.5	2985	68	28	45,68	MH	-	P
SE-14-44-2-W.5	3030	80	25	-	MH	-	P
SE-14-44-2-W.5	3030	154	58	-	H	-	P
5-14-44-2-W.5	3070	90	65	80	MH	6	P
NW-14-44-2-W.5	3060	90	70	-	MH	-	P
SE-16-44-2-W.5	3185	112	60	-	H	-	P
SW-22-44-2-W.5	3185	165	40	151	H	-	P
16-22-44-2-W.5	3010	40	19	30	-	10	P
NE-22-44-2-W.5	3010	48	23	40	H	5	P
NW-24-44-2-W.5	3005	51	34	48	MH	9	P
NE-24-44-2-W.5	3110	130	90	-	H	-	P
NW-26-44-2-W.5	3020	90	60	-	MH	-	P
NW-26-44-2-W.5	3020	120	60	-	MH	-	P
SE-28-44-2-W.5	3075	64	33	-	MH	-	P
NW-31-44-2-W.5	3125	24	12	-	S	-	S
NW-32-44-2-W.5	3095	18	5	18	H	-	S
NW-33-44-2-W.5	3100	118	75	-	S	-	P

Location	Elev.	Depth of well	Depth to wa.	Depth to aquifer	Water type	Yield	P. or S.
SW-35-44-2-W.5	3005	69	22	60	-	-	P
NE-35-44-2-W.5	3045	96	76	80	S	-	P
SE-1-44-3-W.5	2980	80	25	-	S	-	P
NE-1-44-3-W.5	3055	120	40	45	H	-	P
SW-2-44-3-W.5	3050	100	14	-	S	-	P
SW-2-44-3-W.5	3050	18	4	18	H	-	S
SW-3-44-3-W.5	3100	80	60	76	H	-	P
NW-3-44-3-W.5	3040	70	25	-	S	-	P
SE-4-44-3-W.5	3100	35	8	-	H	-	S
NW-6-44-3-W.5	3060	29	5	-	S	-	P
NE-8-44-3-W.5	3045	50	6	40	S	-	P
NW-8-44-3-W.5	3055	80	45	-	MH	-	P
NW-9-44-3-W.5	3050	63	43	-	H	-	P
NE-9-44-3-W.5	3052	76	-	70	MH	-	P
4-10-44-3-W.5	3040	47	3	21,35	-	7	P
NE-11-44-3-W.5	3025	100	10	30	-	-	P
NE-12-44-3-W.5	3055	75	7	45	H	-	P
SE-12-44-3-W.5	3035	30	12	-	H	-	S?
NW-12-44-3-W.5	3020	40	3	-	H	-	P
SW-13-44-3-W.5	3055	35	32	-	H	-	P
SE-15-44-3-W.5	3050	66	12	45	H	-	P
SE-16-44-3-W.5	3075	38	14	-	MH	-	P
SE-18-44-3-W.5	3065	80	60	40,75	H	-	P
NW-18-44-3-W.5	3095	28	20	28	H	-	P
NW-19-44-3-W.5	3215	108	60	-	S	-	P

Location	Elev.	Depth of well	Depth to wa.	Depth to aquifer	Water type	Yield	P.or S.
SE-21-44-3-W.5	3025	60	20	-	H	5	P
SW-21-44-3-W.5	3180	135	95	70	-	-	P
NW-22-44-3-W.5	3065	57	22	55	H	-	P
NE-22-44-3-W.5	3040	20	10	20	MH	-	P
NE-23-44-3-W.5	3075	35	30	-	H	-	P
NW-25-44-3-W.5	3000	115	60	80,100	MH	-	P
SE-30-44-3-W.5	3185	95	80	-	S	-	P
NE-31-44-3-W.5	3090	30	12	-	H	-	P
NW-32-44-3-W.5	3060	13	3	13	H	-	S
NE-33-44-3-W.5	3130	107	17	107	H	-	P
NE-33-44-3-W.5	3145	89	29	-	H	-	P
NW-34-44-3-W.5	3135	74	22	62	varies	-	P
NW-35-44-3-W.5	3225	70	10	20	H	-	P
SW-35-44-3-W.5	3135	18	12	14	H	-	S
SW-36-44-3-W.5	3240	87	57	-	H	-	P
NE-1-44-4-W.5	3080	70	30	-	S	-	P
SE-1-44-4-W.5	3090	7	flows	-	H	-	S
NW-2-44-4-W.5	3052	48	4	48	MH	-	P
NE-10-44-4-W.5	3200	100	35	-	H	-	P
SE-13-44-4-W.5	3053	80	40	-	MH	-	P
SE-15-44-4-W.5	3200	140	-	70	H	-	P
SW-23-44-4-W.5	3090	60	9	-	H	-	P
SE-24-44-4-W.5	3110	60	30	-	H	-	P
NE-26-44-4-W.5	3150	7½	3	7½	H	-	S
NW-26-44-4-W.5	3140	20	10	-	H	-	S?

Location	Elev.	Depth of well	Depth to wa.	Depth to aquifer	Water type	Yield	P. or S.
NE-35-44-4-W.5	3205	50	25	-	H	-	P
NE-35-44-4-W.5	3310	140	110	120	H	-	P
SW-35-44-4-W.5	3200	20	flows	-	H	-	P
SE-36-44-4-W.5	3270	75	60	-	H	-	P
NE-36-44-4-W.5	3248	90	65	85	H	-	P
SE-3-45-2-W.5	3010	45	40	40	H	-	P
NE-3-45-2-W.5	3020	69½	20	40,69	H	-	P
SE-4-45-2-W.5	3050	110	36	70	S	-	P
SW-5-45-2-W.5	3105	75	60	63	H	-	P
NW-9-45-2-W.5	3090	66	33	40	MH	-	P
1-1-45-3-W.5	2980	50	23	40	MH	5	P
SW-3-45-3-W.5	3170	130	40	45	MH	-	P
SW-3-45-3-W.5	3140	105	25	-	H	-	P
NW-3-45-3-W.5	3160	10	8	-	H	-	S
NE-3-45-3-W.5	3200	30	22	-	H	-	P
SE-4-45-3-W.5	3135	130	55	80,120	H	-	P
NW-4-45-3-W.5	3115	150	20	145	MH	-	P
SW-6-45-3-W.5	3215	80	70	35,68	H	-	P
SE-8-45-3-W.5	3100	20	15	-	H	-	S
NE-8-45-3-W.5	3095	70	16	47	MH	-	P
SE-9-45-3-W.5	3125	25	10	-	MH	-	P
SW-12-45-3-W.5	3200	80	20	-	S	-	P
NW-12-45-3-W.5	3145	100	22	-	S	-	P
NW-12-45-3-W.5	3145	90	20	-	S	-	P
SW-15-45-3-W.5	3130	100	14	-	S	-	P

Location	Elev.	Depth of well	Depth to w.s.	Depth to aquifer	Water type	Yield	P. or S.
NW-15-45-3-W.5	3105	65	flows	55	MH	$\frac{1}{2}$	P
SW-15-45-3-W.5	3130	100	14	-	S	-	P
NE-18-45-3-W.5	3095	60	flows	50,60	H	-	P
SE-1-45-4-W.5	3215	60	10	-	H	5	P
SE-2-45-4-W.5	3215	56	17	56	H	-	P

APPENDIX E: LOCATIONS OF SAND AND GRAVEL DEPOSITS

These locations are included to indicate possible groundwater sources and potential sand and gravel pits.

Location	Lithology	
15-31-38-27-W.4	0-50	sand
	50-60	shale
4-34-38-28-W.4	0-35	sand
	35-100	shale and sandstone
16-36-38-28-W.4	0-15	clay
	15-35	gravel
	35-60	shale
4-19-39-27-W.4	0-20	clay and boulders
	20-80	sand
	80-90	gravel
16-20-39-27-W.4	0-20	sand
	20-35	gravel
	35-70	clay and boulders
	70-80	gravel
12-21-39-27-W.4	0-30	sand
	30-60	sandy clay and gravel
	60-75	gravel
16-36-39-27-W.4	0-35	sandy clay and boulders

Location	Lithology
	35-50 pea gravel
4-1-41-2-W.5	0-22 sand and gravel
2-2-41-2-W.5	0-33 sand and gravel
	33-44 blind
	44-95 blind
	95-120 shale
4-2-41-2-W.5	0-50 sand and gravel
4-5-41-2-W.5	0-15 gravel
	15-44 clay and boulders
	44-82 clay and rocks
	82-100 shale
8-10-41-2-W.5	0-40 sand and gravel
16-29-41-2-W.5	0-50 sand
	50-100 clay
16-35-41-2-W.5	0-40 sand and gravel
	40-80 sandstone and shale
16-19-42-1-W.5	0-22 sand
	22-34 clay
	34-80 sandstone and shale
16-20-42-1-W.5	0-28 clay and rocks
	28-44 sand and gravel
	44-12[illegible] sandy clay
3-29-42-1-W.5	0-30 sand and pea gravel
8-31-42-1-W.5	0-24 sand and gravel
	24-118 sandy clay and sandstone
4-5-43-1-W.5	0-12 sand and gravel

Location	Lithology	
	12-42	clay and boulders
	42-60	sandstone and shale
9-7-43-1-W.5	0-30	sand and gravel
	30-40	sandstone
	40-80	sandy clay and rock
1-17-43-1-W.5	0-37	clay and rocks
	37-80	gravel
16-31-43-1-W.5	0- 6	clay
	6-22	gravel
	22-85	sandy clay and sandstone
12-7-43-2-W.5	0-10	gravel
	10-32	clay and boulders
	32-150	sandstone and shale
2-15-43-2-W.5	0-30	sand and gravel
	30-80	sandstone and shale
4-15-43-2-W.5	0-54	sand
	54-80	shale
9-17-43-2-W.5	0-30	boulders and gravel
	30-40	sandstone
	40-80	shale
10-20-43-2-W.5	0-16	gravel
	16-32	sandstone
	32-50	clay
5-29-43-2-W.5	0-40	sand, gravel and sandstone
	40-80	shale

Location	Lithology	
16-35-43-2-W.5	0-10	clay and boulders
	10-36	gravel
	36-81	sandy clay, sandstone
3-4-44-1-W.5	0-55	clay and rocks
	55-85	gravel
	85-100	shale
4-4-44-1-W.5	0-15	clay and rocks
	15-38	gravel
	38-86	clay and rocks
	86-100	shale
4-17-44-1-W.5	0-56	sand
	56-97	clay
	97-150	hard sandy clay, sandstone
4-18-44-1-W.5	0-18	clay and rocks
	18-57	sand
	57-93	clay
4-26-44-2-W.5	0-35	sand
	35-80	sandstone
2-18-44-4-W.5	0-55	sand
	55-70	clay
4-27-44-4-W.5	0-22	clay and rocks
	22-35	gravel
	35-85	rocky clay
	85-110	sandstone

Location	Lithology	
3-2-45-2-W.5	0-10	gravel
	10-20	shale
4-2-45-2-W.5	0-15	gravel
	15-32	clay and boulders
	32-60	shale
10-9-45-2-W.5	0-50	gravel
	50-60	shale
15-9-45-2-W.5	0-20	gravel
	20-40	shale
5-10-45-2-W.5	0-20	gravel
	20-60	shale and sandstone
4-21-45-2-W.5	0-15	gravel
	15-60	shale and sandstone
12-21-45-2-W.5	0-30	gravel
	30-60	shale and sandstone
13-21-45-2-W.5	0-25	gravel
	25-60	shale and sandstone
4-17-45-3-W.5	0-7	clay
	7-32	sand
	32-39	sand and gravel
	39-60	shale

APPENDIX F: VARIATIONS OF GULL LAKE LEVEL

(Courtesy Alberta Water Resources, Department of Agriculture, Edmonton, Alberta)

Temporary Bench Mark - Elevation - 2960.47' (Assumed 100.00')

Location - ½ mile west of the northeast corner 35-40-28-W.4, 65 feet north of fence line.

Sept. 2, 1924	97.04	Sept.29, 1953	91.51
July 17, 1938	94.34	June 15, 1954	92.00
May 5, 1939	94.07	June 27, 1955	93.50
Sept. 8, 1939	93.92	Aug. 9. 1955	93.25
May 21, 1940	94.47	Oct. 5, 1955	92.90
Aug. 12, 1940	93.94	May, 25, 1956	93.27
Sept.24, 1941	92.80	Aug. 7, 1956	93.12
June 2, 1942	92.93	Oct. 29, 1956	92.67
Oct. 16, 1942	92.62	May 16, 1957	92.93
May 19, 1943	92.93	June 18, 1957	92.71
Sept. 8, 1943	92.66	Sept.10, 1957	92.06
April 25,1944	92.32	May 14, 1958	92.45
Aug. 30, 1944	92.82	July 24, 1958	92.08
July 7, 1945	92.47	Dec. 3, 1958	91.56
May 27, 1946	92.98	June 4, 1959	91.43
June 20, 1946	92.47	Oct. 28, 1959	91.04
Feb. 1, 1949	92.72	June 22, 1960	91.29

Sept. [illegible], 1960 9[illegible].82

June 7, 1961 90.69

July 24, 1961 90.[illegible]

Aug. 29, 1961 9[illegible]

June 8, 1962 90.00

Sept. [illegible], 1962 8[illegible].34

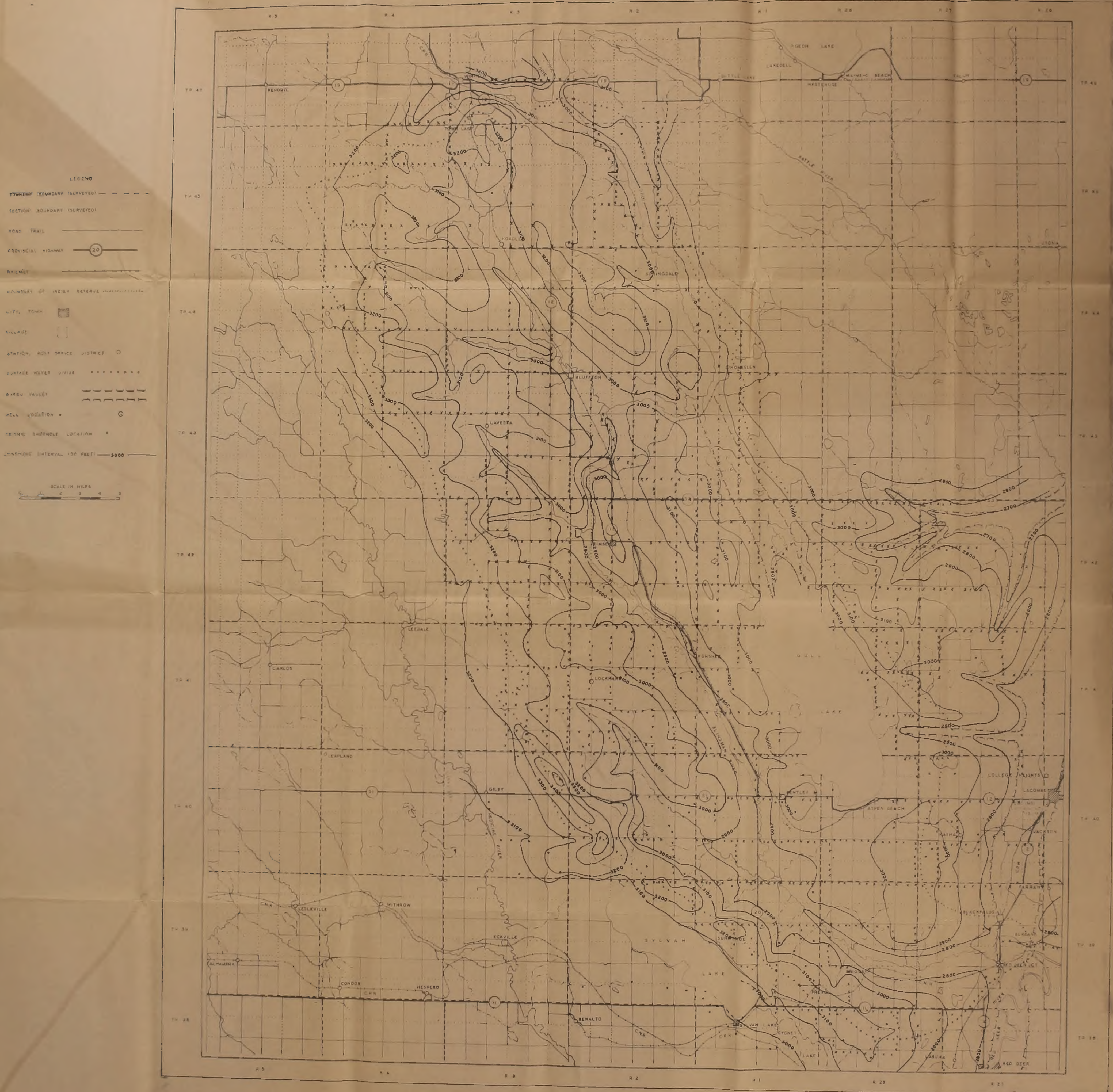

FIGURE 17

BEDROCK TOPOGRAPHY OF THE BLINDMAN RIVER BASIN

FIGURE 18.

CONTOUR MAP OF WATER LEVELS IN WELLS, BLINDMAN RIVER BASIN